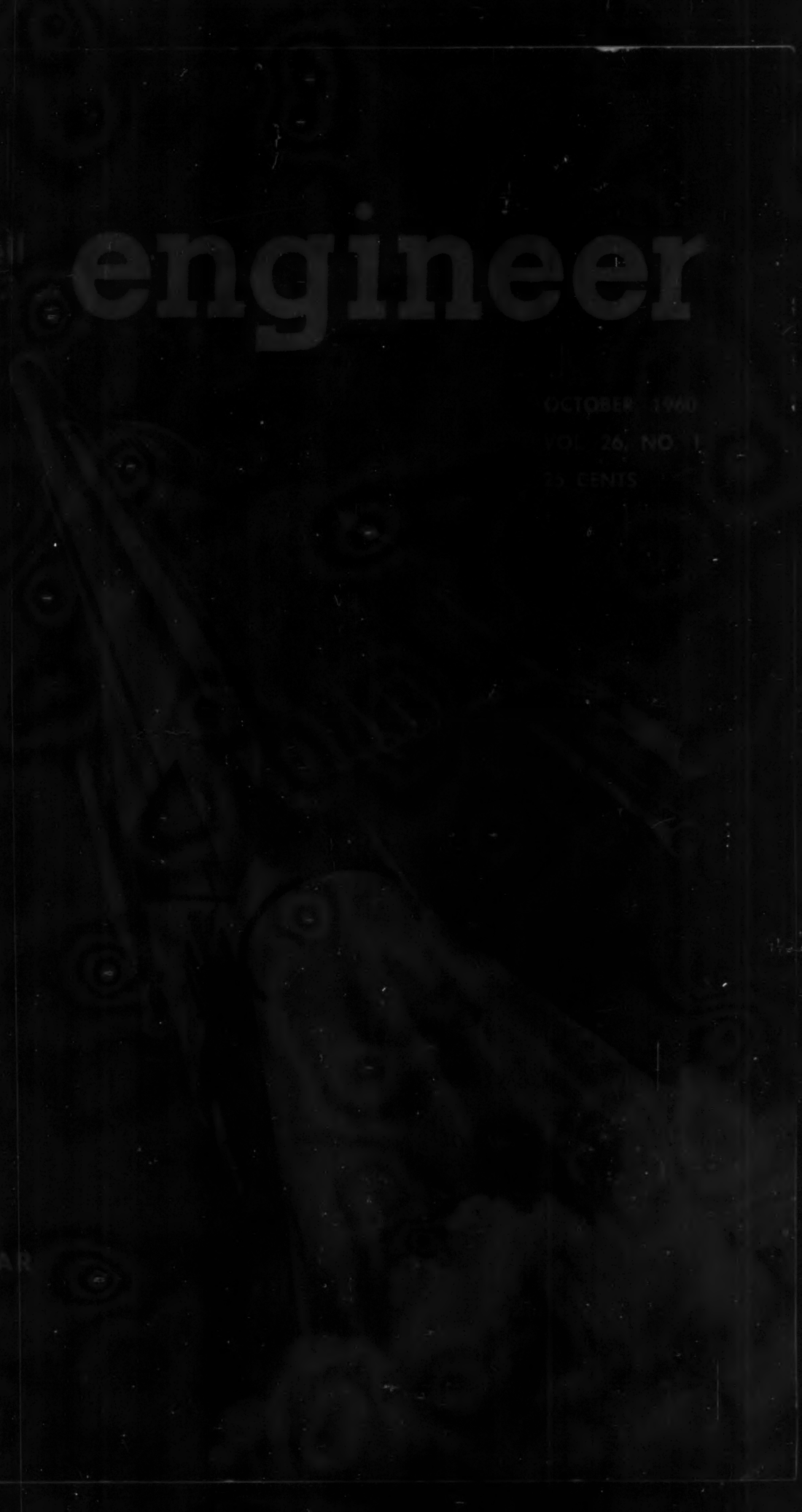
the Cornell

engineer

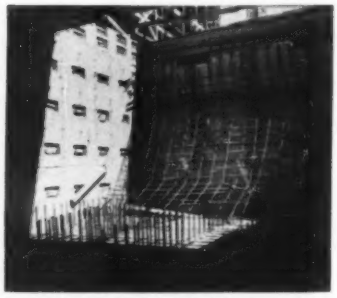
OCTOBER, 1960
VOL. 26, NO. 1
25 CENTS



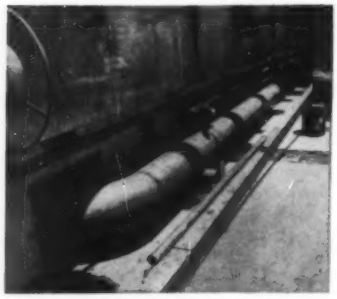
INTERSTELLAR
SPACE
TRAVEL

Somewhere east of Laramie, on one of Wyoming's plains, you'll find the strangest government housing project ever built. Six concrete and steel buildings are being constructed to house Atlas missiles. The site is one of the operational intercontinental missile bases to be operated by the Strategic Air Command. This base is being constructed on the surface. Others will burrow deep into the earth.

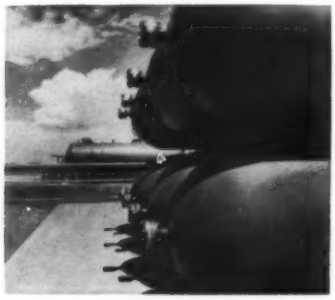
The U. S. Army Corps of Engineers is constructing this operational intercontinental missile base in Wyoming. In front of the partially completed Launch and Service Buildings are Col. Sidney T. Martin, in charge of construction, and Maurice K. Graber, a construction engineer for the Corps.



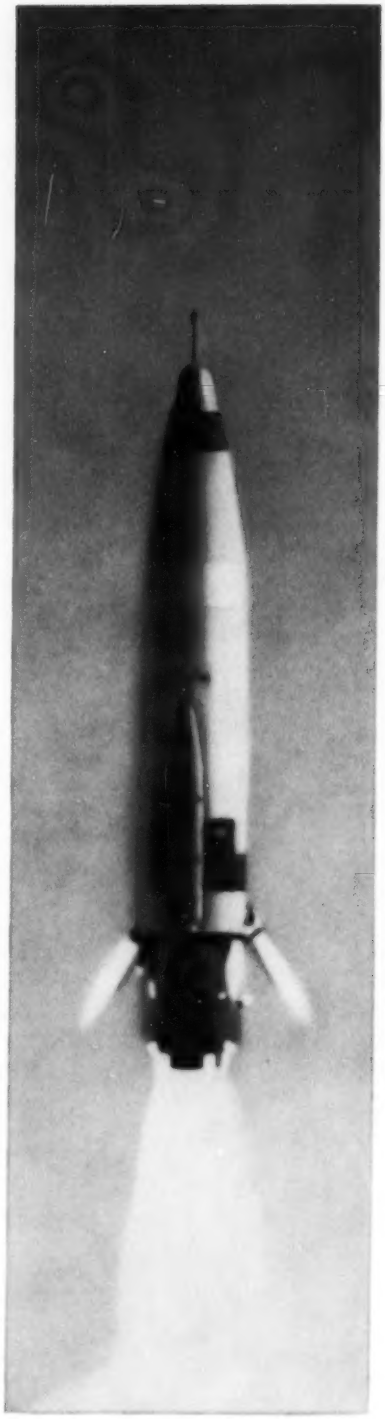
This is the inside of the blast pit of one of the launcher buildings. In all six of these buildings there are 1,040 tons of structural steel, 1,950 tons of reinforcing steel, over 48,000 tons of concrete aggregate, blocks and cement, and 8,040 tons of mechanical steel items.



Fuel lines and process piping are Stainless Steel and operate at pressures up to 15,000 psi. The pipes are kept almost surgically clean to prevent contamination of fuel and subsequent malfunction. Vapor degreasing and chemical cleaning processes are used on the pipes.



The Atlas is powered by a cluster of liquid propellant rocket engines that burn liquid oxygen and RP-1, a kerosene-like hydrocarbon fuel. 192 pressure tanks fabricated from alloy or Stainless Steel plate at this site store liquid and gases —liquid oxygen and nitrogen and helium gases which are used to inject the fuels into the missiles.



The missiles are all you ever hear or read about. Actually, they're only a small part of the missile program. Most of the manpower and material go into ground support equipment. There are over 11,000 tons of steel and over 48,000 tons of concrete aggregate, blocks and cement in the six launching service buildings at this site alone.

United States Steel can supply virtually all of the material for a missile program — carbon steels, high-strength low-alloy steels, ultra-high-strength alloy steels, Stainless Steel, steel fence, electrical cable, cement and wire rope.

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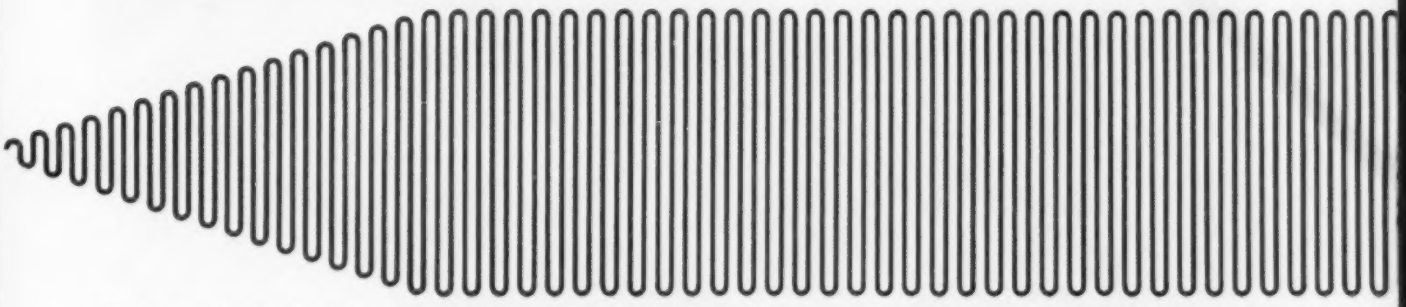
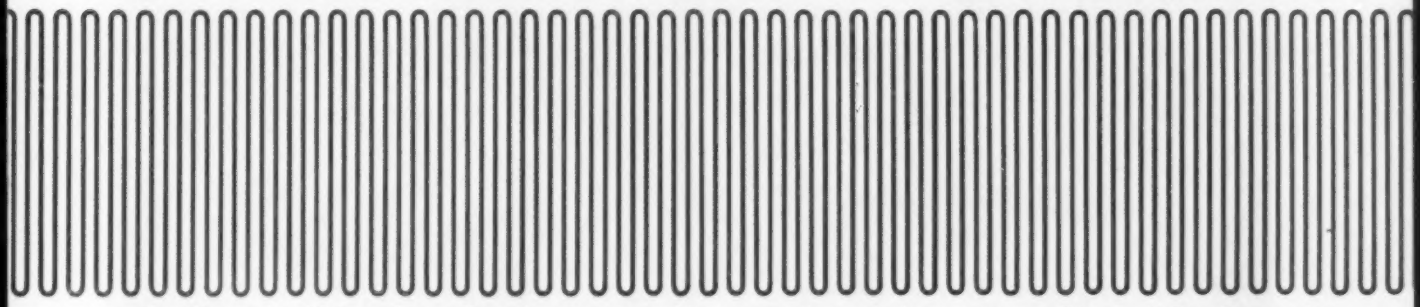
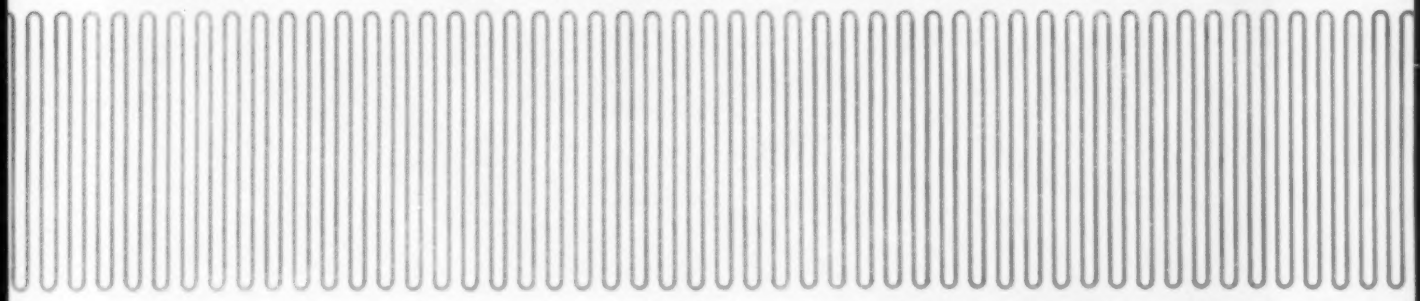
Things we know about tomorrow: Sound waves like these will wash dishes, disperse



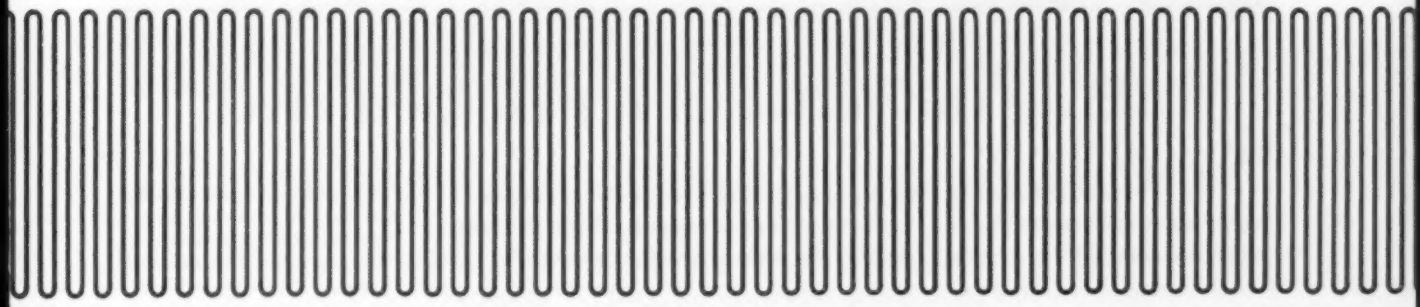
fog, make chemical reactions go faster. Ultrasonic waves can weld one metal to another without heat. Help decontaminate



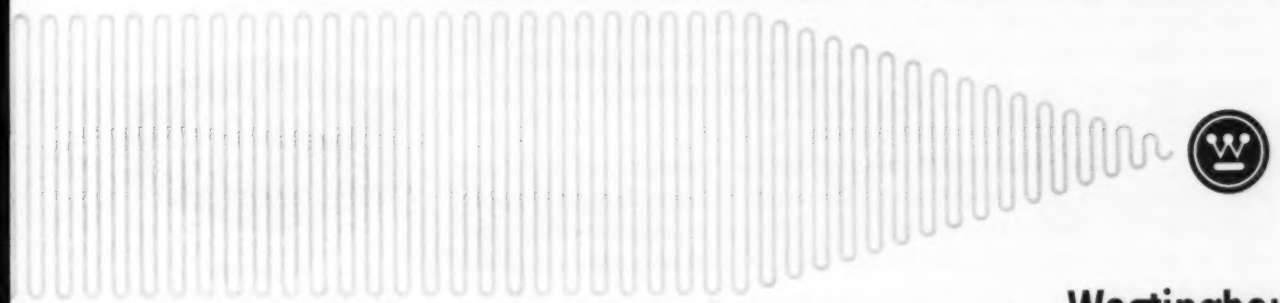
radioactive parts. Make solder adhere to almost anything, even glass. Perform surgery without a knife. Change the



flavors of foods, and the crystals in a steel ingot. Ultrasonics is a major research and development area at Westinghouse



. . . and another reason why Westinghouse is the best place for talented engineers. For more information write L. H.



Noggle, Westinghouse Educational Department, Pittsburgh 21, Pa. You can be sure if it's **Westinghouse**

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Taking the pulse of a petrified river

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Finding, refining, and researching the materials used in atomic energy are all part of the work done by the people of Union Carbide to enrich your daily life. With pioneering curiosity, they are seeking new things not only in atomic energy, but also in the fields of carbons, chemicals, gases, metals, and plastics.

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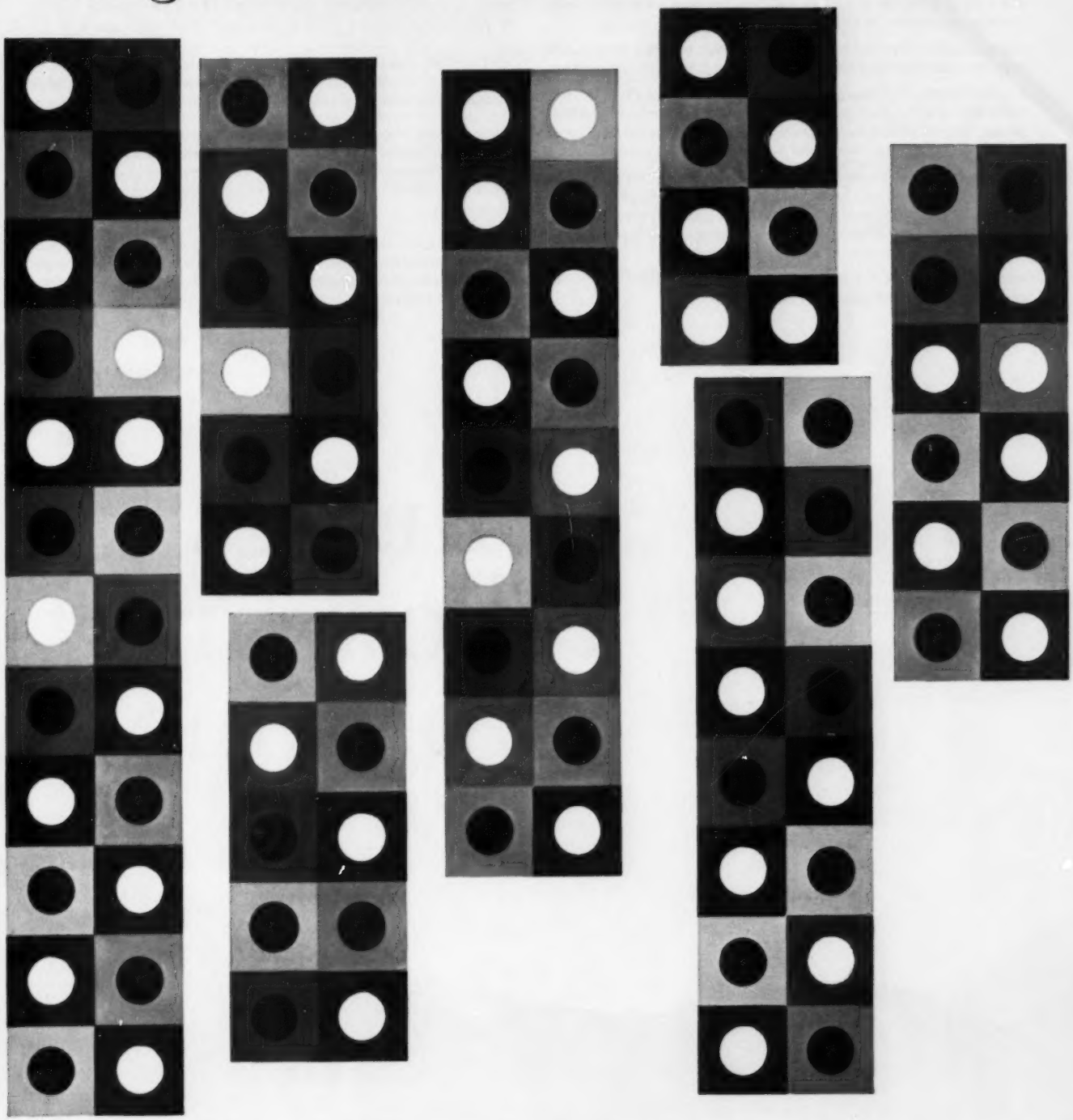
Things we know about tomorrow:



10,000 traffic signals controlled by a computer.

Imagine a computer that could solve the downtown traffic problem. This is the long-range potential of a new kind of computer invented by Westinghouse, one that "learns" by experience, and adapts instantly to changing problems. One pilot model has been running a refinery process. Tomorrow this new-concept computer will improve the making of cement, paper, and almost anything else made by a continuous process. Compared to standard computers, it will be smaller, cheaper, more reliable.

Interest in tomorrow is one reason Westinghouse is the best place for talented engineers. For more reasons, write L. H. Noggle, Westinghouse Educational Department, Pittsburgh 21, Pa.

You can be sure . . . if it's

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HUGHES MASTERS FELLOWSHIPS. The Hughes Masters Fellowship Program offers unusual opportunities for education leading to a master's degree... and, in addition, provides each fellow with practical experience in the professional field of his choice.

Approximately fifty new awards will be made in 1961 to qualified applicants possessing a bachelor's degree in science or engineering.

A selected group of award winners will be offered a **FULL STUDY PROGRAM.** Participants in this program will receive fellowships that permit them to attend an outstanding university on a full time basis during the regular academic year with a substantial stipend.

Other award winners will be assigned to the **WORK STUDY PROGRAM** and will attend a university sufficiently near a facility of the Hughes Aircraft Company to permit them to obtain practical experience, in a professional field of their choice, by working at the company half time. An appropriate stipend will also be awarded.

After completion of the Master's Program, fellows are eligible to apply for HUGHES DOCTORAL FELLOWSHIPS.

HOWARD HUGHES DOCTORAL FELLOWSHIPS. If you are interested in studies leading to a doctor's degree in physics or engineering, you are invited to apply for one of the several new awards in 1961 on the Howard Hughes Doctoral Fellowship Program.

This unique program offers the doctoral candidate the optimum combination of high-level study at an outstanding institution plus practical industrial experience in the Hughes laboratories.

Each Howard Hughes Doctoral Fellowship provides approximately $8,000 annually. Of this amount approximately $1,800 is for tuition, thesis and research expenses, other academic fees and books. The remaining amount is the award of a cash stipend and salary earned by the fellow.

Howard Hughes Doctoral Fellowships are open to outstanding students qualified for admission to graduate standing. A master's degree, or equivalent graduate work is essential before beginning the Fellowship Program.

Hughes Fellowship Programs

For both programs, typical areas of research and development to which fellows may be assigned while working for Hughes include: weapons control systems, infrared search and track systems, advanced propulsion systems... parametric amplifiers, masers, lasers, microwave tubes and devices, electron-tube and solid-state displays, semiconductor materials, antenna arrays, aerospace vehicles... plasma electronics; solid state, atomic, nuclear and aerospace physics; propagation, mechanics of structures, chemistry and metallurgy... systems analysis, human factors analysis, network analysis and synthesis... microminiaturization, communications, data processing, information theory, simulation.

The classified nature of work at Hughes makes American citizenship and eligibility for security clearance a requirement.

Closing date for applications: January 15, 1961.

How to apply: To apply for either the Howard Hughes Doctoral Fellowships or the Hughes Masters Fellowships write Dr. C. N. Warfield, Educational Relations, Hughes Aircraft Company, Culver City, California.

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Editorials . . .

THE ENGINEER INVITES YOU . . .

"Which activity should I choose?" For the engineering student interested in journalism, business, photography, or art work, the *Cornell Engineer* provides an ideal answer. The magazine offers its staff members innumerable opportunities to learn and to create, and serves their non-technical as well as their technical interests. While on an *Engineer* board, the member will extend his knowledge beyond his own curricular study to a share in the latest scientific and engineering developments. Through association with professors and other students, he will view the many colors of the engineering spectrum and observe how they blend to produce today's technology.

One of the most important skills a young engineer can acquire is that of self-expression. Ideas, no matter how clever, can be of no benefit unless they are communicated. Although the graduating engineer may be well qualified to solve problems in his field of study, his curriculum has not trained him to set these solutions forth to others in a clear and concise manner. To those who wish to develop their expressive ability, the *Engineer* offers the opportunity in its editorial training program. Staff members find practice in writing and editing a valuable aid to logical and precise thinking, and consequently an asset both in the classroom and later in the industrial world. Experience gained in the *Engineer* office also helps the student learn principles of good business practice and management.

In addition to these immediate benefits, staff members may also discover new career possibilities open to their consideration. The field of engineering journalism needs young engineers to help industry keep informed of the most modern developments through technical magazines. Careers in management await graduates with engineering training and business experience. Qualities of leadership and cooperation learned in *Engineer* work will prove useful in any phase of the profession.

The Cornell Engineer invites all who are interested to visit our offices and meet our board members. Competitions, starting soon, will be open to all freshmen and upperclassmen throughout the fall term. We are certain that those who complete our training program will find staff membership a rewarding and enjoyable experience. – M.A.H.

ACTIVITIES—A PART OF EDUCATION

Activities at Cornell provide one of the best additions to an education. Most of us will remember what we have learned in our activities long after the courses are forgotten. They offer the student many opportunities to broaden and develop himself not found in the curriculum. He may, for example, develop leadership talents or an active imagination. He will learn how to deal with people and will find a much needed relaxation from his studies.

Nowhere in the Cornell catalogue can we find a course which will teach the student the art of being a leader. This just can't be taught with books or in a classroom situation, partially because the teacher must always maintain the position of leadership. It is an art developed through experience, and experience is precisely what the activities, fraternities, and some of the living units offer. In each of these there is always a job to be done, a project to be undertaken, or enthusiasm to be encouraged. This takes leadership—leadership which is encouraged and solicited from each member. Most activities expect each member to hold a position or office of responsibility during his membership. And, due to graduation and the rapid membership turnover, everyone gets his chance. All make mistakes, but through these they learn.

Imagination is one of the most valuable assets of an engineer, but if it isn't challenged it declines. It is too bad that the courses don't provide more challenge to the imagination, but the student will encounter this challenge in activities. These organizations always need new ideas because if one becomes stagnant it ceases to receive support and dies. Their life is constant change, and every member must contribute.

Beside these two most important qualities the student will gain various technical skills depending upon what activity he joins. He will gain a wider viewpoint in many ways and increase his contacts with the faculty on an informal basis. And he will be able to get away from the books for a few hours and participate in the good times enjoyed by all. – R.T.F.

Founded in 1885

THE CORNELL engineer

OCTOBER 1960 VOLUME 26 No. 1

COVER This is an artist's conception of a nuclear-powered space ship. With the advent of advanced propulsion systems, with highly-improved specific impulse, a space journey for $3 a pound would be possible.

Martin Company

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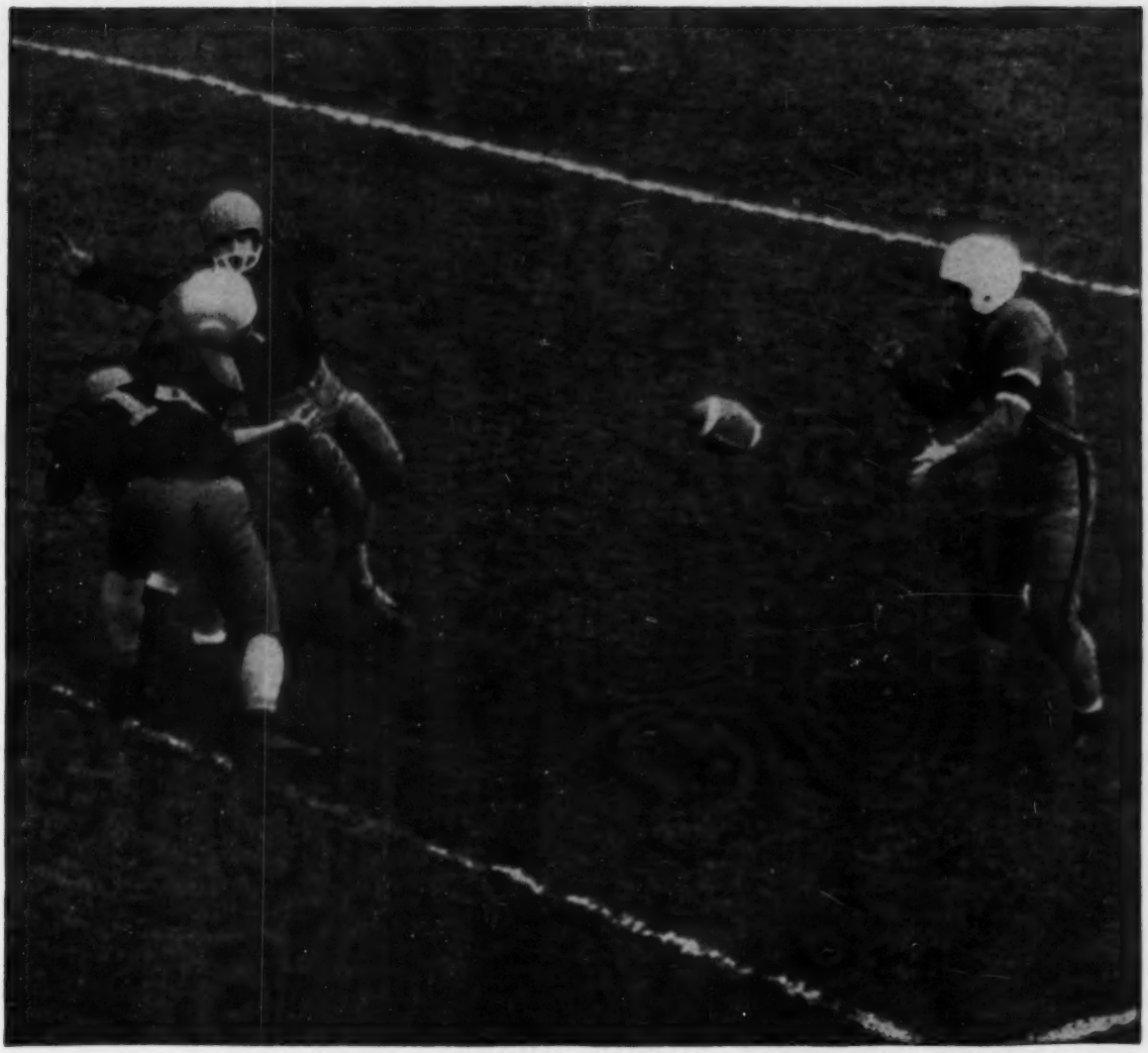

How to advance through lateral movement

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You'll never be buried at Koppers. You'll never stand still intellectually. Moving from one operation to another, you'll move ahead. Your assignment won't be to learn just a job, but many jobs. Your compensation? Advancement, responsibility, success.

Your youth won't be held against you. Neither will short tenure. If you have the ability and the desire to get ahead, you'll move fast! Our system of continuous appraisal and evaluation is your guarantee of that.

Koppers is so widely diversified that you can almost name your job. Want to work with chemicals, jet-engine sound control, plastics, sintering plants, wood preservatives, road surfacing materials, electrostatic precipitators? Interested in research? Production? Sales? These are only a few of the fascinating opportunities at Koppers.

Why not find out how you can fit into the Koppers picture? Write to the Personnel Manager, Koppers Company, Inc., Room 230, Koppers Bldg., Pittsburgh 19, Pennsylvania. Or, see your College Placement Director and arrange an appointment with a Koppers representative for the next recruiting visit.

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On the riddle of rolling friction

General Motors is pioneering research into the mystery of energy losses in the rolling ball. With a unique measuring device (above), investigators have not only confirmed the hypothesis of how a rolling ball loses energy (Answer: elastic hysteresis), but have also learned where this lost energy is dissipated (Answer: in the interior of the material, not on the surface).

The effectiveness of automation depends upon the ingenuity of the scientist and engineer. If you are about to begin a career in the field of technology you'll benefit yourself by working where ingenuity and enthusiasm pay off. At General Motors they do, and in a big way.

What is your main interest? GM's diversification covers many fields. Automotive research, production engineering and manufacturing, electronics and astronautics are just a few. With so many and varied divisions, GM can offer men who qualify the choice of specialization or the opportunity to work on vastly different projects.

If you are an undergraduate, or if you are working on a postgraduate degree, GM has a financial aid program that you should look into. For complete information, write to General Motors, Personnel Staff, Detroit 2, Michigan.

GENERAL MOTORS

GM positions now available in these fields for men holding Bachelor's, Master's and Doctor's degrees: Mechanica , Electrical, Industrial, Metallurgical, Chemical, and Ceramic Engineering • Mathematics • Industrial Design • Physics • Chemistry • Engineering Mechanics • Business Administration and Related Fields

Why college men choose careers with Du Pont

Every year, several hundred new college graduates choose Du Pont. Many Masters and Ph.D.'s do, too.

From time to time we learn from recent graduates the factors which led to their decision to join this company. They cite more than half a dozen reasons. Here are four of the most important:

OPPORTUNITY AND RECOGNITION

They were aware that college-trained beginners go right to work with men who have achieved.

For example, research chemists work with individuals who've done successful research. New engineers work with pros, some of whom have designed new plants, or devised new manufacturing methods, or distinguished themselves in some other way. And other graduates, with B.A. or M.B.A. degrees, go to work with leaders who've been successful in Sales or Advertising or Treasurer's, or another of Du Pont's many departments.

They had been told—and rightly—that Du Pont rewards individual achievement. And they were eager to start achieving.

RESEARCH CREATES NEW PRODUCTS; NEW PRODUCTS CREATE NEW JOBS

Men like working for a company that believes in research, enough to invest in it... $90 million a year!

The fact is that important new products come from Du Pont laboratories and go to Du Pont manufacturing plants with frequency.

Here are but a few since World War II: "Orlon"* acrylic fiber followed nylon (soon after the war). Then came "Dacron"* polyester fiber, "Mylar"* polyester film, "Lucite"* acrylic lacquer and "Delrin"* acetal resin.

These, and many others, have created thousands of new jobs... in research, manufacturing, sales... in fact, in *all* Du Pont departments.

DU PONT BACKS EMPLOYEES WITH HUGE INVESTMENT

New graduates feel that every facility is provided for doing the job well.

Last year, Du Pont's operating investment per employee was $32,500. Since much of this was expended to provide the most modern and best of equipment to work with, it further increases the chance for individual achievement.

This applies to men in lab, plant and office.

DU PONT PROVIDES STEADY EMPLOYMENT

Career seekers appreciate the importance of security.

Today, the average annual turnover rate at Du Pont is less than one-third that of industry nationally.

• • •

These, and many other reasons, draw new talent to Du Pont each year.

Prospective graduates, M.S.'s and Ph.D.'s interested in learning more about job opportunities at Du Pont are urged to see their Placement Counselor, or to write direct to E. I. du Pont de Nemours & Co. (Inc.). They should tell us the course they are majoring in so we can send literature that is most appropriate.

DU PONT

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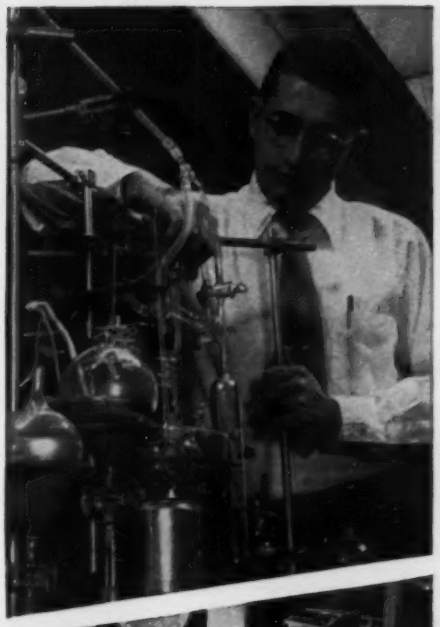
* REGISTERED DU PONT TRADEMARK



Earth's resource limitations may lead man to

INTERSTELLAR SPACE FLIGHT

by John W. Hughes, EP '64

Speculation on the subject of manned journeys to other solar systems, formerly exiled to the realms of science fiction, has become a matter for the scientific journal. Although the vastness of "deep space" is beyond comprehension, travel to the stars is more than fantasy, however filled with unknowns it is at present. We now possess the basic requirements of space flight—engineering skill and the pioneering drive. Within a matter of decades we shall have reached the boundaries of our solar system. What opportunities, mysteries and dangers will confront us when we then venture into interstellar space?

Necessity for Space Travel

An indisputable fact is that the earth will someday be incapable of sustaining human life. This will probably occur because of the gradual "burning out" of the sun, although a random collision with another celestial body, such as a planet-sized meteor, is possible. While the probability of the occurrence of such an event will remain small for several million years, the fact remains that we must eventually leave the earth and seek a similar environment beyond our solar system. Because a majority of the stars can be expected to possess systems of planets, at least some of the many billions of planets should approximate the conditions found here on Earth. Thus, our drive for self-preservation could bring about expansion by way of the stars.

Eventually mankind must face the overpopulation of the earth and the exhaustion of our natural resources. Unless a system of voluntary "depopulation" is developed, we will be forced to colonize extra-terrestrial regions. This could be accomplished by huge "space-transports" reminiscent of the colonization of America by the early settlers from Europe.

Perhaps the greatest incentive to interstellar flight is man's inherent instinct to probe unknown places and things. Even in a society characterized by the homogenizing tendencies of industrial progress, there are still many who possess the desire to leave the confines of earth.

Nature of the Universe

The greatest obstacle to interstellar flight lies in the colossal distances involved. As more powerful telescopes come into use, the boundaries of the universe are pushed farther and farther away, with no end in sight. Some of the galaxies which our telescopes receive light from today gave off the light millions of years ago. Our sun's nearest neighbor, Proxima Centauri, is over four light years away. A spaceship theoretically traveling at the speed of light would take at least four years to make the trip. Many stars in our own galaxy would take hundreds of years to reach.

A further complication, at least to intergalactic flight, is that the galaxies seem to be moving away from each other at tremendous speeds. Much scientific interest has been generated by Dr. Thomas Gold, of Cornell's Space Center, who believes that the universe is in continual balance, and that it expands outward as creation proceeds at its center. He also espouses the idea that life on this planet evolved from the microbes left by some unknown "spacemen" who visited the earth eons ago, and that we will continue the cycle, spreading life to other planets of the universe.

An interesting facet of space flight may be the forms of life that we find on other planets. We may find a multitude of sociological, moral and ecological problems when we contact an alien form of life, particularly if this form is superior to us. Many scientists have suggested that the only means of communication available will be by elementary geometric forms, such as right triangles and circles. In addition, space travelers who come upon an alien planet which is evolutionarily younger than the earth might find themselves in the midst of mentally less-developed beings such as dinosaurs.

Space and Relativity

Since the speed of light is the theoretical upper limit to the speed of a spaceship, much controversy has centered on the probabilities of achieving semi-optic speeds. Some scientists even believe that we could reach this goal within the next hundred years, with the aid of photon or ionic propulsion systems. If man were traveling near the speed of light he could visit other stars and return to Earth within his lifetime.

Relativistic and not classical laws govern the flight of a spaceship. Classical theory states that a rocket ship traveling at velocity V which receives an additional vel-

High-thrust missiles such as this liquid-fueled Atlas will be used to overcome the earth's gravitational field and atmosphere. The interstellar part of the journey will then be made by ionic or other high-velocity thrust space-craft.
General Electric

ocity V′ would have a final velocity of V + V′. Relativistic theory, however, states that

$$V_{final} = \frac{V + V'}{V + \frac{VV'}{c^2}}$$

Thus a vehicle moving at 0.9c (c = speed of light), and given an increment of 0.1c would have a resultant velocity of less than c (.918c, to be exact).

In addition, as we approach the speed of light, several complications are introduced. One, as stated in the Lorentz Transformation, was discovered by Hendrik Lorentz, a Dutch physicist. Based on electrical and magnetic laws, it asserts that the length of a body with initial length L′ decreases with increasing velocity:

$$L = L' \sqrt{1 - \frac{V^2}{c^2}}$$

(L = relative length of the body in motion)

Thus c is the upper limit for velocity, for at c the length equals zero. He also stated that a body theoretically approaching c would have a mass approaching infinity, or

$$m = \frac{m'}{\sqrt{1 - \frac{V^2}{c^2}}}$$

m = relative mass of moving body
m′ = initial mass

Another effect of near-optic speeds is the time-dilation effect. This states that the interval of time experienced by an observer in a fixed coordinate system will be greater than that experienced by an observer in a moving spaceship. The relationship between the two quantities will follow the same pattern as that between m and m′.

Escape and Propulsion

Before concerning himself with the problem of space navigation, man will have to free himself of the earth's, and then the sun's, gravitational fields.

Thrust, F, is given by the formula:

$$F = u \frac{dm}{dt}$$

where u equals the exhaust velocity of the vehicle and dm/dt equals the mass exhaust flow of propellant. The thrust potential of a method of propulsion is expressed in terms of the specific impulse, which is the thrust in pounds supplied per pound of propellant consumed.

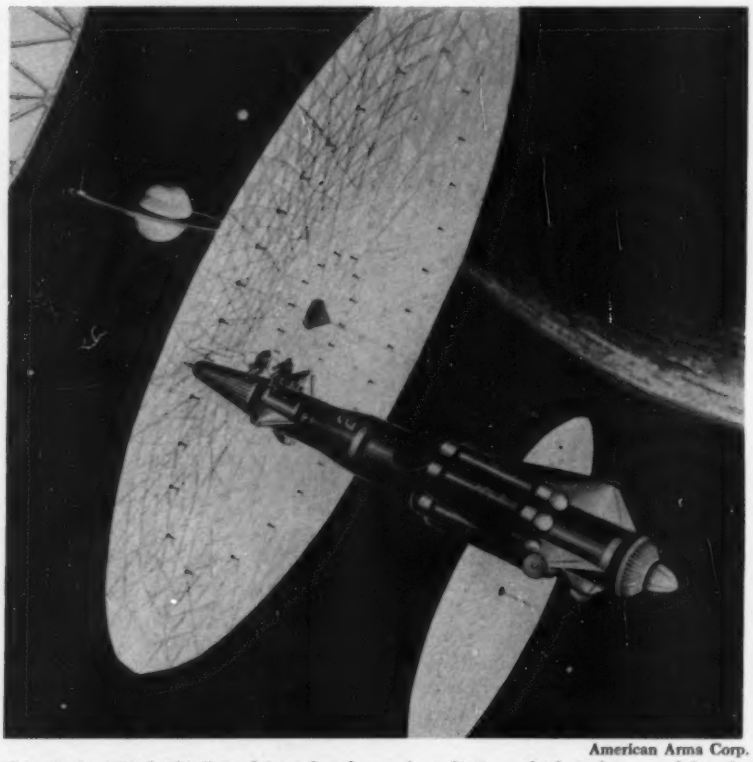
Chemical propulsion, used extensively in modern rocket systems, will probably be used only for atmospheric or interplanetary flight, due to its low specific impulse (200–400) and the weight of fuel that must be carried.

Atomic fission has been the most frequently proposed propulsion medium for spacecraft. The specific impulse of a nuclear-powered craft would range from 500 to 1,000. In such a system, the heat from the atomic reaction is used to heat the exhaust gas, which will probably be either hydrogen or methane. However, a severe radiation hazard would threaten the crew, and heavy shielding or isolation of the nuclear reactor would be necessary. Fusion reactions would give off a great deal more energy than fission, but would also require extensive shielding.

For crossing intersteller space, where low thrusts and high exhaust velocities are desirable, the ion rocket has been proposed. Its principle involves the acceleration of ions in a preordained direction by an electrostatic field. The ions are produced by subsequent vaporization and ionization of the propellant, and they leave the ionization chamber at extremely high speeds.

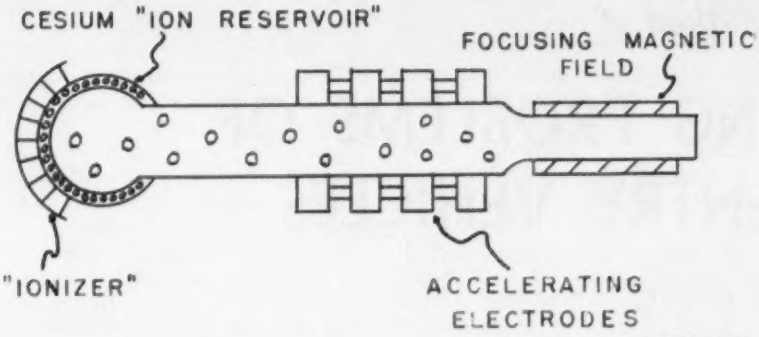
Other proposed systems of propulsion are the photon and the anti-gravity methods. Photon rockets will be powered by beams of light produced by a high temperature working fluid. Since the light will leave the ship at a velocity equal to c, the spaceship can be expected to travel at fairly high fractions of c. Gravity-propelled rockets will work on the principle of neutralizing the force of gravity. Spontaneous accelerations to infinite speeds are then theoretically possible.

Combinations of these propulsive systems have also been proposed. In one such proposal, a



American Arms Corp.

This "Solar Wind Ship" is driven by the sun's radiation which is harnessed by the aluminum coated plastic sails, several miles in diameter. In the center of the sail is the hull, which can revolve in any direction and thus provide artificial gravity for the crew and at the same time act as a stabilizing gyroscope. In the foreground a group of astronauts enters the small ferry rocket towed behind the ship.



Andy Morris

An "ion accelerator" for use with ion-propelled space ships.

chemical or nuclear system would provide the thrust necessary to free the ship from the sun's gravitational field, and ionic or photonic propulsion would supply the semi-optic velocities needed for interstellar flight.

The Spaceship

The successful design of a spaceship will entail considerations of both technical requirements and human frailties. Low weight and great strength are important propulsive considerations. Shields or outer shells may be utilized to cope with the dangerous problem of meteors. Delicate instrumentation will be charged with the duty of running the ship in case of human inabilities, especially on long voyages when man may fail to adjust to the environment found on a space vehicle. For example, communication with our solar system from distances of many light years may be impossible for a spaceship to achieve. Even powerful transmitting devices could fail to pierce the wall of galactic interference. And, provided they could, it might take years to get an answer.

The science of "space medicine", which deals with the reactions of the human organism to an alien environment, has achieved considerable progress in recent years. The use of algae for food and oxygen, and the reclamation of useful elements from bodily waste have been objects of much experimentation. In gravitation–less space artificial gravity can be created by spinning the spacecraft about its axis. The resultant centrifugal force gives a feeling of weight to objects within the ship. Of course, the axis of the ship will be the "up" direction, and the floors will be curved in a direction parallel to the axis.

A number of other ideas, often fantastic, relating to the problems of spaceflight have been formulated by astronautic experts, science fiction writers, and others. To overcome the time barrier involved in long flights, suspended animation of the entire crew during flight has been proposed. Another idea is "generation travel", in which a miniature society would be transported on a generations-long journey into space. Of course sociological problems would stem from the fact that whole generations would have to spend their entire lives on the spaceship. However, as research continues we may find answers to these and other problems, particularly if science can prove Einstein wrong and can surpass the speed of light.

The importance of interstellar flight will increase in the years to come as man's curiosity drives him farther and farther into the universe. The difficulties, technical and otherwise, will greatly surpass those which he experiences on earth. However, a short four hundred years ago the greater part of our earth was undiscovered, and the stars were considered mere ornaments on the "celestial vault". Who can say what man, aware of the challenge of the stars, can achieve in the years to come?

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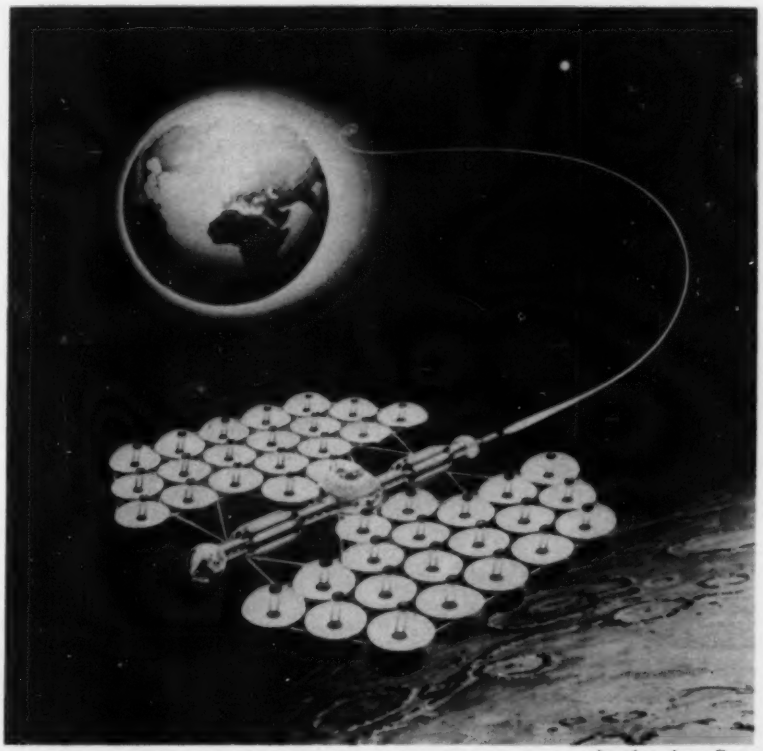


American Arma Corp.

This "Cosmic Butterfly" attempts to absorb solar energy by a number of fifty-foot parabolic mirrors which concentrate the sun's rays on a boiler located at the focal point. This in turn drives an ion rocket which uses cesium as the propellant.

Missile designers seek solutions of

HEATING PROBLEMS OF RE-ENTRY VEHICLES

by Robert L. Kaplan, EE '64

The successful re-entry of a missile into the atmosphere is, without a doubt, one of the biggest sources of the problems facing missile scientists today.

A missile is composed of a nose cone and a booster system. The nose cone is accelerated by the booster system to a given velocity and altitude in space. At this point, it separates from the booster, follows a ballistic trajectory through space, and re-enters the earth's atmosphere at a speed of about 14,000 miles per hour. The exact angle and velocity at which it re-enters are dependent upon the required range and trajectory. The design of the nose cone depends almost entirely upon the conditions it will encounter during the re-entry phase.

To see how it is possible for a nose cone to re-enter the atmosphere and survive the plunge, we must consider two problems. The first of these is how to obtain maximum reduction of heat during the re-entry phase, and the second is how to handle the heat that is unavoidably generated during this period.

Blunt Nose Cones

Reducing the heat caused by atmospheric friction is one of the most important problems in the design of any re-entry vehicle. The first major breakthrough in the re-entry problem was made five years ago in the laboratories of the National Advisory Committee for Aeronautics. The discovery, made by Dr. Harvey Allen, was that a blunt nose cone will reduce the heat input to any vehicle entering the atmosphere at a high velocity. Dr. Allen's studies began with an analysis of the velocity and deceleration of a missile entering the atmosphere. A blunt body starts decelerating sooner than a sharp-nosed body. This is because the blunt or rounded body offers more resistance to the air and is slowed down very quickly, while the streamlined body would go plunging on toward the earth. The blunt-nosed object, therefore, reaches its peak deceleration at high altitudes, where the atmosphere is greatly rarified. This region of peak deceleration is roughly the same region where maximum heating occurs. Because the air is rarified, the friction caused by the re-entry vehicle moving swiftly through the air is reduced tremendously and, as a consequence, not as much heat is generated.

Perhaps the most important characteristic of a blunt nose cone is that it contains more surface area than a pointed cone. The maximum heat that reaches a missile, called the peak heat flux, is a function of the ballistic parameter. For our needs, the ballistic parameter equals the weight per unit front area. For nose cones made of the same material, as the front area gets larger, the ballistic parameter becomes smaller. A low ballistic parameter produces a low peak flux and less heat is able to be transfered to the vehicle's nose cone. The sharp-nosed cone will therefore reach a higher temperature than the blunt nose cone because in the blunt cone, the same amount of heat is spread over a larger area.

A blunt or rounded nose cone entering the atmosphere will cause a shock wave to be repelled or bounced off the rounded front surface and *away from* the rest of the vehicle. During the test of a Mercury capsule, typical of a re-entry vehicle, it re-entered the atmosphere traveling at 14,000 mph. The blunt shape of the heat shield plowing into the atmosphere slowed the missile to approximately 500 mph, a reduction to almost 1/30 the original speed, in only two minutes. As a rule of thumb, the heat flux increases or decreases as the cube of the velocity. Thus, the heat flux was diminished to $(1/30)^3$ the original amount. A large amount of this diminished heat goes along with the shock wave and the re-entry vehicle requires less protection for heating.

Flat Approach Angle

The heating of a re-entry vehicle may also be reduced by using flat approach angles. When a re-entry body comes down on a flat approach angle, it curves towards earth only slightly and takes a long time to reach the ground. The big advantage of the flat approach angle is that the heat input is spread over a long time interval. Thus, any area receives less heat per unit time, and this gives the nose cone sufficient time to absorb and store the heat without softening or melting.

No matter how effectively the transfer of heat is reduced, a large amount of heat, on the order of thousands of B.T.U.'s, will still be transferred to the nose of the re-entry vehicle. Under ordinary circumstances, this heat is high enough to soften and melt ordinary materials. This is why re-entry objects, such as meteors, burn and disintegrate long before they reach the surface of the earth. Methods and materials must therefore be devised that can handle these high temperatures.

Heat Sink Method

The first method of handling the heat created by a body re-entering

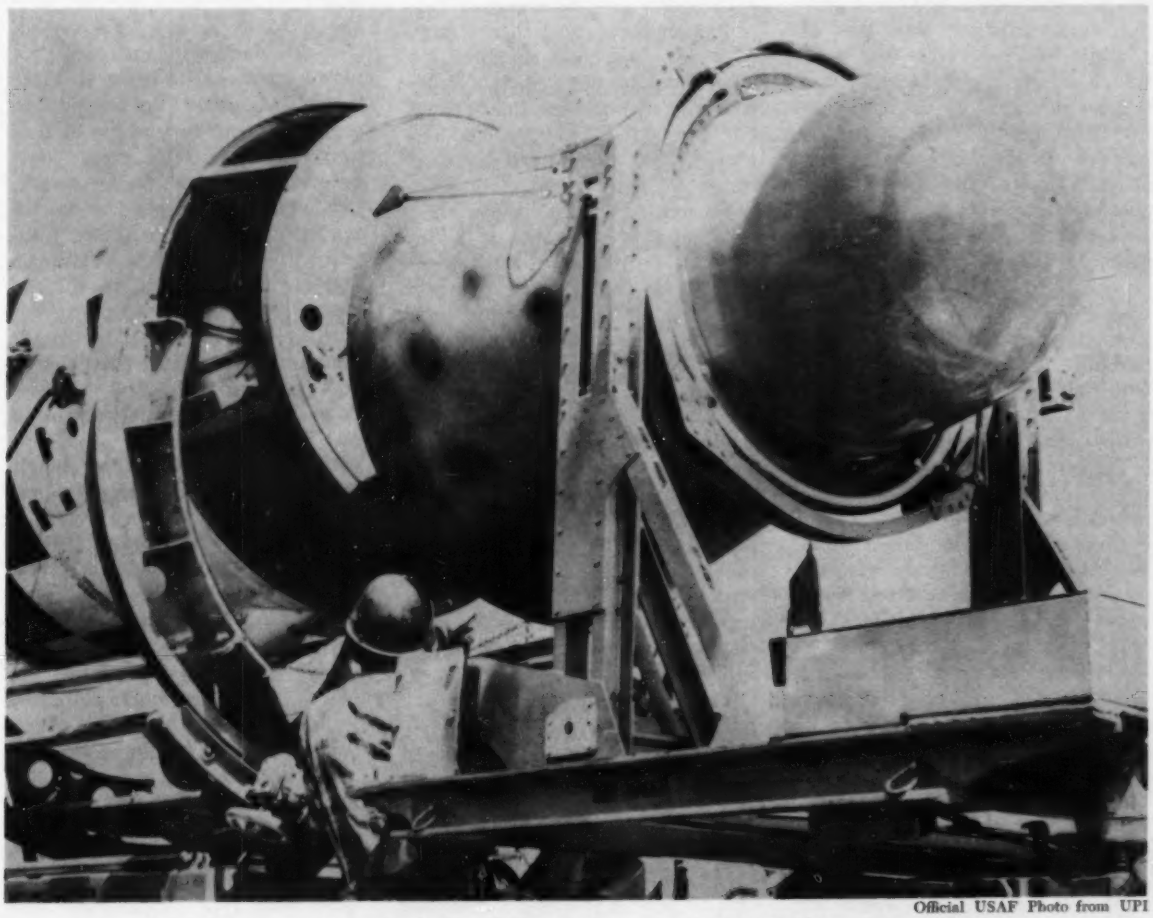
the atmosphere is known as the heat sink method. The principle of the heat sink nose cone is the absorption and storage of heat by the nose cone surface. A good heat sink material must have high heat capacity and a high thermal conductivity. High thermal conductivity is necessary so that the heat can be carried away from the surface of the nose cone before the surface temperature builds up to the melting point. All materials have limited heat capacity and rate at which they can conduct heat. The heat sink problem is to find a light material which can absorb a large quantity of heat while remaining structurally sound.

The National Advisory Committee for Aeronautics subjected four classes of materials to these specifications. The first class to be subjected were the heavy ductile materials, such as copper. These materials were found to have the advantageous qualities of high thermal conductivity, not too low a melting point, and low specific heat. Low specific heat means that it takes a large quantity of heat to raise the temperature of the material. Copper does have one drawback; it is quite heavy. In spite of this, it has so many good qualities that it was judged, for the present, the best material of all the classes tested.

The second group of materials tested are known as refractory metals. Inconel–X is the outstanding example of this group. Inconel–X has a very high strength-to-weight ratio. Unfortunately, the refractory metals were judged to be completely unsatisfactory because of their very low rate of thermal conductivity (the heat wouldn't spread out quickly and evenly). The Inconel–X surface would reach its melting point while the rest of the material had experienced practically no temperature rise, and the surface would begin to melt.

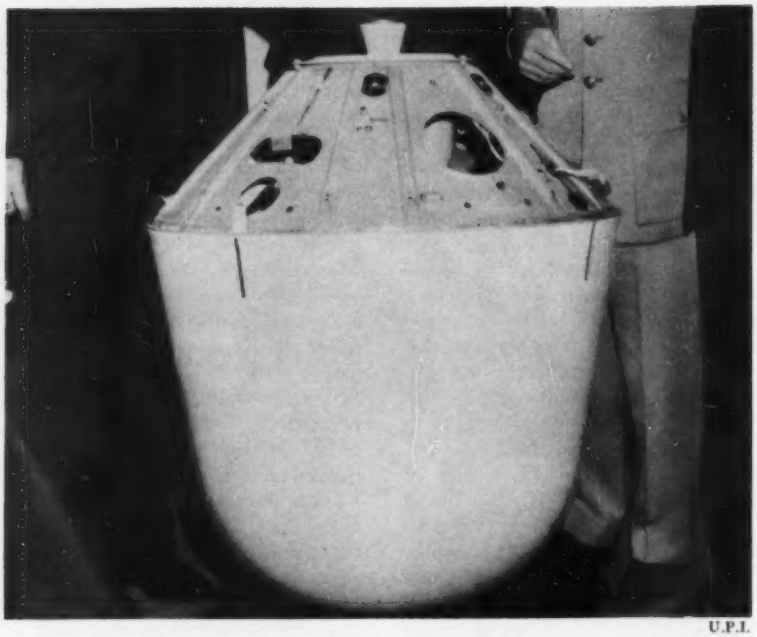
The third group of materials tested were the lightweight metals, such as beryllium. Beryllium was found to have, perhaps, the best potential of all the metals tested. It is considered excellent because it has all the favorable properties of copper, and in addition has a high strength-to-weight ratio, distributes the heat well, and is superior to copper in terms of weight. The use of beryllium would result in a sixfold saving of weight as compared with copper. On the other hand, beryllium is highly toxic, brittle, and extremely difficult to form into the large sections necessary for a nose cone. Forming of beryllium into large sections has proved so difficult and so time consuming that it has rendered beryllium, for the time being, impractical for use in quantity orders of nose cones. A beryllium heat sink has been forged for the Mercury Astronauts, but this heat sink is only a test model.

The fourth class of materials tested by the NACA were the



Official USAF Photo from UPI

An ablative nose cone holding the life support and recovery capsule for the Discoverer satellite program.



U.P.I.

Discoverer XIII satellite nose cone: The blunt shape of this ablative heat shield was an important prerequisite for the successful recovery of this historic nose cone.

semi-metals. Graphite (carbon) is the material in this group offering the most promise. The use of graphite in a nose cone would result in a huge saving weight, as it weighs only 1/24 as much as copper. Also graphite has a unique property in the high temperature field. Its strength increases with increasing temperature until it has almost doubled at about 4,300 degrees Farenheit. In spite of this property, graphite, in comparison with copper or steel, still has low strength. A graphite surface would probably have to be protected with anti-oxidation coatings in order to minimize graphite's tendency toward oxidation.

The copper heat sink re-entry vehicle has been successfully flight tested over a wide range of re-entry conditions. The data capsule, in which test conditions were recorded on tape, has survived water impact and has been recovered intact from a large number of flights. The development of the copper heat sink nose cone has been justified by these flight tests. Local surface melting has not occurred and internal components received their necessary thermal protection.

For a heat sink to be effective, there must be no surface scratches or pits. These defects will interrupt the laminar, or smooth, air flow over the nose cone and cause the air flow to become turbulent. A turbulent air flow is a much better conductor of heat than a laminar flow and will conduct too much heat to the vehicle. Therefore, the use of heat sink designs for long range missiles requires considerable attention to manufacturing tolerances, and close tolerances mean great expense.

Although it is possible for a nose cone to absorb more heat by adding to the thickness of the heat sink, this additional weight soon becomes prohibitive in terms of takeoff weight. The additional weight could be put to better use, such as for more fuel or a heavier payload. Heat sinks have a limitation in that they can conduct heat away from the exposed surface only so fast. If the heat isn't conducted into the interior rapidly enough, catastrophic melting occurs. The heat sink acts as a large reservoir where heat can be conducted, but it is a reservoir with a limited capacity.

Ablation

To satisfy the requirements of less weight and lower cost of thermal protection, a new approach was needed and ablation was the answer. The principle behind ablation is simply that a material will absorb heat as it changes from one physical state to another. A material will thus absorb a large quantity of heat from the surrounding material as it melts and then vaporizes.

The major problem was to find a light material which could be fabricated easily and would heat evenly. If the material didn't heat evenly, it would vaporize more on one side, causing that side to become lighter. By having an unbalanced weight, the vehicle would not go straight to its target.

Unlike a heat sink material, ablative material should have very low thermal conductivity. This is necessary so that the surface temperature can build up to the melting point and vaporize while the material just below the surface will remain comparatively cool and will retain its structural strength.

Of immediate interest for ablation work is the group of polymer systems commonly referred to as reinforced plastics. For very short periods of time (calculated in seconds), reinforced plastics have the ability to withstand temperatures above 5,000 degrees Fahrenheit. One manufacturer claims to have a plastic that has withstood more than 10,000 degrees Fahrenheit. For comparison, the melting point of iron is about 2,700 degrees – only a fourth as much as the plastic. Plastics are also light, easy to fabricate, and are reasonably inexpensive. The reinforced plastic re-entry will not ablate in the accepted sense of the word. It will act more as a heat blocker than as a heat remover. As the plastic melts and then vaporizes its vapor will flow into the boundary layer of fast flowing air above the nose cone. By entering this layer, it will change the heat transfer coefficient between the two layers. As a result, less heat can be transmitted to the missile. This alteration of the boundary layer is known as mass transfer.

It was found that if Refasil (96% silica) were used instead of some of the other constituents of the reinforced plastics, the new plastic was able to absorb three times as much heat for each pound ablated as previously. This is about 40 times better heat absorption per pound than copper. The favorable properties of such a laminated glass-resin type of ablation heat shield include high liquid viscosity

at high temperatures, low thermal conductivity, good thermal stress, and high energy of evaporation. Upon melting, the viscocity must be very high to prevent the liquid from being blown away.

Much work must still be done to perfect ablative techniques and materials. The next logical step in the development of superior ablative materials is the study of certain additives, such as carbon, to produce even lower thermal conductivity and lower thermal expansion without any serious loss of ablative resistance.

Fluid Cooling

The final method of cooling a re-entry vehicle is by the use of fluids. There are two types of fluid cooling. The first is called "sweat" cooling. In this process, a fluid, such as water, is forced out of the pores of a nose cone. The fluid would boil because of the high temperature of the nose cone. When water, or any other liquid, boils, the heat necessary to raise its temperature to the boiling point is removed from the surface in contact with it (in this case, the nose cone) and would consequently lower the temperature of this adjoining surface.

The second type of fluid cooling is called regenerative cooling. A fluid is circulated within a jacket of pipes located just beneath the cone's surface. The fluid absorbs the heat transmitted to it. Both these processes have their limitations. Whether the fluid could be moved fast enough to do the job, and whether the weight of this equipment, including the weight of the fluid, might not weigh more than would the material required for some other means of protection, are questions which must be considered in the design of the cone.

In conclusion, the heating problems of a re-entry vehicle appear to be solved. Perhaps the final proof was offered a few months ago when it was announced that the final design of the nose cone capsule for the Mercury Astronauts had been chosen, and the first flight of man into space, protected and housed in a nose cone of the heat sink variety, will take place in the summer of next year. The time, money, and energy spent on solving the re-entry problem were surely great, but the rewards of this research will, without a doubt, prove to be far, far greater.

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Famous mathematicians contributed to

THE DEVELOPMENT OF THE SLIDE RULE

by Gary M. Mills, Arts '63

Engineers today make constant use of a slide rule. Yet few of them understand its theory and still fewer, its history.

Long History

With early number systems, computation was difficult. Therefore it is not strange to find that a number of devices to aid computation were invented by the ancients. Many of these devices with slight modification are used widely today. Some of the first aids were various tables, such as the multiplication table and tables of squares and cubes. These tables, seen everywhere today, were used by the Babylonians more than 4000 years ago.

But by far the most important device for mechanical computation prior to the slide rule was the abacus. In the hands of a skilled operator, the abacus is as efficient as the most modern adding machine. Most of our meters for measuring gas, electricity, and water are mechanical adaptations of the abacus. Even almost all of our rather complex computing machines, so widely in use today, are highly developed mechanical abaci.

Into this list of early devices would fall such helpful tools as proportional compasses, Galileo's sector compass, early surveying instruments (e.g. plane table and quadrant), and many more. Then came the giant of all mathematical inventions, logarithms, and with logarithms, the slide rule.

Invention of Logarithms

John Napier, the inventor of logarithms, was a man of many talents. He was born in 1550 near Edinburgh, and was educated at St. Andrew's University. Early in his life he demonstrated his keen inventiveness by devising a type of submarine for his country's fleet. Napier was also one of the first to use the decimal point in expressing decimal fractions in a systematic way, as in the modern system of decimal notation.

However, Napier is noted popularly for none of the foregoing items. Rather, he is best known as the inventor of the first system of logarithms, described in his *Canonis Descriptio* (1614).

Henry Briggs, an English mathematician who was a contemporary of Napier, proposed a modification to Napier's system. The Napierian logarithms are natural logarithms to the base e. Briggs proposed a system in which unity is taken as the logarithm of the ratio of 10 to 1, i.e. decimal logarithms. Napier agreed and in 1617 Briggs published the revised system. Even today, logarithms to the base 10 are known as Briggsian logarithms while logarithms to the base e are known as Napierian logarithms.

Evolution of the Slide Rule

The slide rule, which almost immediately followed Briggs and Napier, differed from all the previous computing instruments in that the slide rule had its basis in logarithms. Napier had published his work on logarithms in 1614. Six years later, Edmund Gunter made a logarithmic scale and used it for mechanical computation. To compute with his scale, Gunter used a pair of dividers instead of sliding one scale along a duplicate one. Ooughtred improved on Gunter's method of manipulating the scales by laying two of Gunter's scales side by side.

Ever since the time of these men, there has been a constant evolution of the slide rule, extending over its history of more than three hundred and fifty years. In 1630 came Delamain's circular slide rule. In 1664 Bissaker invented a slide rule in which the sliding scale moved between two fixed elements, as in modern slide rules. It was thus more than thirty years after Gunter that the slide rule appeared somewhat like its present-day form, and nearly one hundred and fifty years after him that the runner or indicator was made a fixed part of it.

The slide rule became quite popular for a time in England. At this time Sir Isaac Newton invented a method for solving cubic equations by use of three parallel logarithmic scales. Samuel Pepys, in his *Diary*, considered the slide rule "very pretty for all questions of arithmetick." These early slide rules, however, were usually poorly made and lacked many important features of the modern rules. Also, even when compared with today's inflationary costs, the price of one of these early slide rules was extremely high.

In the seventeenth century, decimal fractions were not yet in general use, and the slide rule is of little value without decimal fractions. However after the metric system and extended use of decimals became common, more inter-

est in the use of slide rules was shown. In 1850 Lieutenant Mannheim of the French army developed the rule that bears his name. This became the standard rule in France and slowly increased in popularity in England and even in the United States.

The United States has made several technical improvements on the slide rule. In 1891 an American company introduced an entirely new idea in slide rule construction which made it possible to have scales on the front and back surfaces of the slide rules, and to have a double indicator that could refer to all scales simultaneously.

Around 1900, to the basic C and D scales were added the folded scales CF and DF, and the inverted folded scale CIF. These scales reduce considerably the amount of manipulation and slide resetting needed for extended multiplication and division. These scales were originally folded at 10, but they were later improved by folding them at pi. Pi can now be used as a factor without making a separate setting for this value.

Growth of Popularity

The first college in the United States to make the slide rule a required part of its engineering curriculum was Washington University in St. Louis, Missouri (in about 1880). By 1890 a number of schools were beginning to use the slide rule. Still the high cost of slide rules hampered their wide use in schools. It was a long time before there were any really satisfactory inexpensive rules, but there are now a number of them on the market. The lowering of the price has made possible the introduction of the slide rule into the high school.

In high school, and even in college, teaching of the use of the slide rule has caused much difficulty. Since the slide rule is based on the decimal system of notation, it is necessary for slide rule students to have a thorough knowledge of decimal fractions and of all phases of computation with them. Some time spent in reviewing decimal fractions is therefore necessary before trying to teach slide rule usage. Some difficulty is also due to the fact that the slide rule is an instrument for rapid *approximate* computation. In all their previous training, students have been accustomed to carry results to as many as six or eight supposedly significant figures. Because of this conditioning, they feel that the results obtained by the use of the slide rule are not sufficiently accurate to be of much value.

Make Your Own

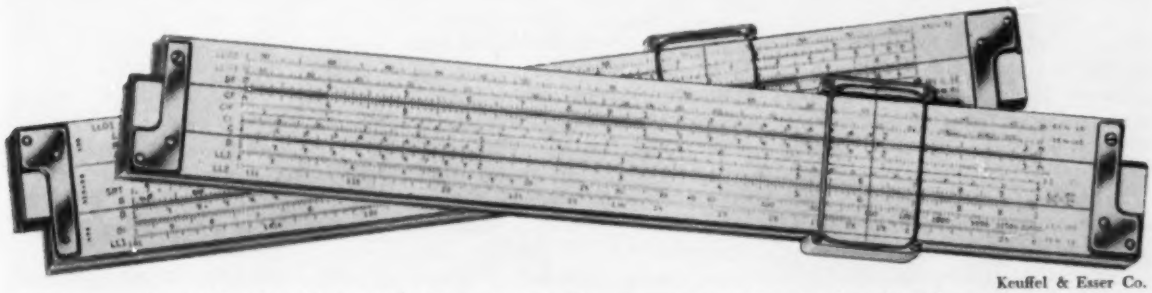
All inventions have underlying principles, and the slide rule is no exception. A simple slide rule is not difficult to make, and it will best illustrate the relation between logarithms and the rule itself. It is easier to use a 10 centimeter scale than the usual 10 inch scale, because metric measure is based on the decimal system.

1) Draw a line 10 cm. (100 mm.) long.
2) Measure from the left a distance corresponding to log 2. Since log 2 = .3010, the length is approximately 30 mm. Mark the figure 2 at the end of this distance.
3) Again beginning at the left, measure the distance corresponding to log 3. Since log 3 = .4771, the length is approximately 48 mm. Mark the figure 3.
4) Proceed with the other one-digit numbers as described above.
5) To make this geometric computation easier, find log π and denote its position.
6) Divide the distance between figures 1 and 2 into ten equal parts. These can correspond to logs 11 – 19. This is only an approximation, but on this small scale, the approximation is within 1%.
7) In the same manner make divisions between 2 and 3, 3 and 4, etc.
8) Duplicate the work of steps 1 – 7 on another appropriately sized piece of cardboard.

From the above directions, a simple slide rule can be made. These two workable scales are comparable to the C and D scales of the commercial slide rule.

The value of the slide rule as a time saver in the solution of problems cannot be overestimated. A single setting of the slide rule will give a result that would require a tedious multiplication, division, or other arithmetical operation. Two or three successive settings may give an answer that could be obtained only by a page of long-hand calculations. Unfortunately the slide rule remains a thing of mystery to many who would be benefited by a knowledge of how to use it. Yet there is no real mystery about it, and the methods by which it is used are simple and direct.

The slide rule has proved to be a boon to engineers the world over. It has resulted in the emancipation of the scientist from the drudgery of time-consuming arithmetic computation. And to the ancient skeptic who asked, "Is there anything whereof it may be said, 'See, this is new'?" Napier, Gunter, Oughtred, Mannheim and many others may answer, "The slide rule, the mechanical logarithm table."



Keuffel & Esser Co.

When properly used, the slide rule can eliminate much of the time-consuming mathematics that slows down an engineer.

Greater efficiency, cost control are goals of

OPERATIONS RESEARCH AND THE INDUSTRIAL ENGINEER

by David S. Kessler, ME '62

During 1959, one of the nation's largest and most progressive companies reorganized the engineering sections whose job it was to plan the manufacturing facilities of the company. As a result of this reorganization, a new department emerged. It was called "Industrial Engineering," but in comparison to the former industrial engineering departments, the new department had a vastly broader function:

"To investigate, evaluate and plan for decisive action; assist and direct other plant functions in the analysis, measurement, improvement and control of costs associated with the total manufacturing system."[1]

As for how the change affected various engineering personnel, the former "industrial engineer" never used a computer to solve problems. He was formerly located in the Materials Handling Department which, unlike his new department, had a very specific function. Whereas he previously used tried and tested principles, he now employs the latest mathematical techniques of a growing science, operations research. Contrary to being tried and tested, operations research techniques set precedents by a constant use of new applications of theory.

This company is just one of the many firms, both large and small, that are torn between old philosophies and new trends. The new trend, one frequently discussed whenever industrial engineers gather at professional meetings, is the rapid absorption of operations research techniques into industrial engineering. This topic should be of interest both to the undergraduate who has a strong mathematical background together with a knack for attacking challenging scheduling and planning problems, and to the alumni engineers who are ambitious enough to delve into new aids to their work.

History of Industrial Engineering

Industrial engineering can be generally defined as the application of the engineering approach to all factors involved in the manufacture of products or services. But this definition does not attempt to define the limits of industrial engineering. This is a source of confusion, both to students of business organization and to engineers.

The origins of this confusion date back to the early 1900's when such famous engineers as Lillian Gilbreth, Frederick W. Taylor and Lawrence Gantt first laid down the principles of scientific management, a scientific study of business. From the very beginning there were ambiguities which translated themselves into overlapping functions. Part of the confusion and indeed much of the adverse criticism resulted because of the term "scientific management."

In spite of the initial unpopularity, many people adopted this new profession. These professional men, engineers by training, called themselves industrial engineers. The early concepts were a foundation upon which today's industrial engineering structure was built. The areas of activity expanded and presently include those activities which are directly concerned with the effective use of mechanical appliances and hence with their adaptations to the human element. Activities range from plant and office layout through work methods and planning, the reduction of material and labor costs, simplification and standardization, to base-rate analysis and quality control." Engineers working in all of these areas had a common objective: to seek ways of reducing production costs.

The growth of the new profession was rapid. It was not long before new techniques such as charting devices and other visual aids were being devised. Such tools as flow process charts, operation process charts, man-machine charts and Gantt charts permitted qualitative analysis of industrial problems.

It was not until just prior to World War II that quantitative analytical methods were introduced. Their first uses included determining economical lot sizes, standard data, and materials handling equations.

Even at the outset of World War II, when statistical quality control and work sampling were first used, actual use of analytical methods lagged. Engineers and management were content to make decisions in an arbitrary manner, either by rule of thumb or by use of intuition or opinion. It was not until operations research analysts renewed interest and inspired confidence in analytical techniques with successful war time applications that industrial engineers sat up and took notice.

Operations Research

What is operations research? How does it work, and just how effective is it?

There are many definitions of O.R. in use today, but all center about the same idea—use of a scientific approach to solve industrial problems. Certain people might argue that this definition also describes industrial engineering, but O.R. tries to go further. It tends to consider more facets of the problems—to give the company a more effective overall solution. It searches deeper for underlying causes and relationships. And it tries to relate

factors which never before could be considered quantitatively. A more effective overall solution—not very complimentary to industrial engineering.

That O.R. does offer more effective solutions is becoming less questionable every day, as more and more successful applications are reported. Its use can be illustrated by the following example: Assume a group of mechanical engineering professors discovers a new method of mechanical design that results in more functional and economical designs. This group might very well be able to set themselves up as "functional analysts" specializing in the application of their new technique. Then if a design problem arises, the functional analysts could be called. The ordinary mechanical engineer would be relegated to a position of secondary importance. In a similar manner O.R. techniques rose to prominence during World War II.

The initial use of operations research was in a military context. The initial development took place in the United Kingdom. Earliest uses were in determining the optimum number of bombers for a bombing mission and the deployment of ships in a convoy, and also in the control of supplies. In almost all cases the team approach was used. A team was composed of men who had different backgrounds and training. One such team might have included a general, a mathematician, a logistics expert and various other specialists, each of whom had something to contribute toward the solution of a problem.

After the war O.R. moved into business, industry and government. Adoption of the new techniques was at first slow, but since 1951, O.R. has taken hold and developed rapidly. The team approach was so successful that it was carried over and is still a widespread practice today. The teams don't operate differently from the wartime teams, except that an inventory control specialist has replaced the logistics expert and a production supervisor performs the tasks that the general formerly did. Here are other basic characteristics of operations research.[2]

1. O.R. deals with the assignment of quantitative values to various parts of a problem. It tries to find relationships between these parts.
2. O.R. emphasizes the use of mathematical techniques, especially probability theory and statistical analysis.
3. Basic approach to problems is through a mathematical model. This working model takes the form of a probability expression which can be manipulated more easily than other forms of expression (e. g. a picture or graph cannot be fed into a computer as input data).
4. O.R. is concerned with optimizing one or more basic requirements of a system. It also attempts to uncover interdependencies and does both without ever making use of a pilot model or mock set-up of any kind.

How does it accomplish this? Let's take a closer look at a few O.R. techniques.

Queuing

The current industrial engineering approach to work systems problems employs a type of analy-

Neophytes in operations research have been going back to the classroom to learn about new techniques in industrial engineering.

sis generally considered to be of a static nature. That is, the engineer or analyst makes extensive use of operation charts which show how a process or system is currently operating, or how a proposed system should operate. It is true that the industrial engineer of today uses some quantitative methods in expressing input and output data, but the conditions that exist when the data are gathered are such that he comes up with an "average" set of conditions, or even merely a model which depicts a certain single outcome. The automobile industry is an example of a business which experiences many fluctuating conditions. If average machine or assembly times were gathered over the period of a year in order to determine how a new production line might look, the resulting picture would be inaccurate, to say the least, because the industry experiences peaks and valleys in production.

The problem, then, is a dynamic one. Parameters and certain dimensions of the system are constantly changing. Obviously the static approach to a problem of this sort would be incorrect. What means are there of dealing with a dynamic situation? There are four effective methods of solving this problem.[3]

1. Observe the existing system, noting variations of performance. However, this method necessarily limits the evaluation of alternative proposals because the alternates presumably are not in operation anywhere.
2. The next logical method is to set up experimental or pilot models of the various alternatives. The drawback is the prohibitive cost of undertaking such a venture.
3. Physical models of the proposed systems could be constructed. Analog computers are now programmed to simulate such things as space flight or radar installations.
4. A fourth method is the use of mathematical and analytical techniques. The problem is solved through the use of equations. It is as a result of the use of this fourth method that operations research is gaining prominence. One of the most common applications of the mathematical technique occurs in the simple queuing problem.

All queuing problems are characterized by the existence of a facility which renders service to discrete customer units which demand this service from time to time.[4] Examples of queuing problems are trucks waiting to be loaded at a loading platform, ticket lines, and machinists getting tools at a tool crib. Four characteristics that *distinguish* one queuing problem from another are the manner in which units arrive to receive a service, the nature of the service time, the number of service stations available and the special queuing rules, called queue discipline, that are to be observed.

There are several problems connected with the use of queuing theory. One problem is that assumed time distributions very often do not come reasonably close to approximating the actual conditions that exist. Furthermore, a reasonable distribution may exist, but the equations become too difficult to manipulate. Another drawback is that most of the solutions are valid only after the system has been in operation for some time.

Because of its complexity and limited accuracy, queuing theory is being bypassed today in favor of a more recent technique of operations research – "system simulation."

System Simulation

The systems simulator that industrial engineers and operations research analysts talk about is a mathematical simulator which attempts to duplicate actual working conditions on paper. Queuing theory is a type of simulation, but it is very different from systems simulation, which is concisely defined by Professor Dr. Dimitris Chorafas of the IBM World Trade Organization as a working analogy. Simulation involves construction of a working mathematical or computer model which presents the similarity of properties or their relationships to the physical system under study. In this manner, the optimization of a system's characteristics can be determined.

Simulation has the advantage of being simple and easy to understand. It eliminates the need for costly trial and error methods of trying out new operating concepts, because input data can be easily changed and the effect on a facility readily ascertained. The actual area in question is never altered until the results of the simulation study show which alternative is best.

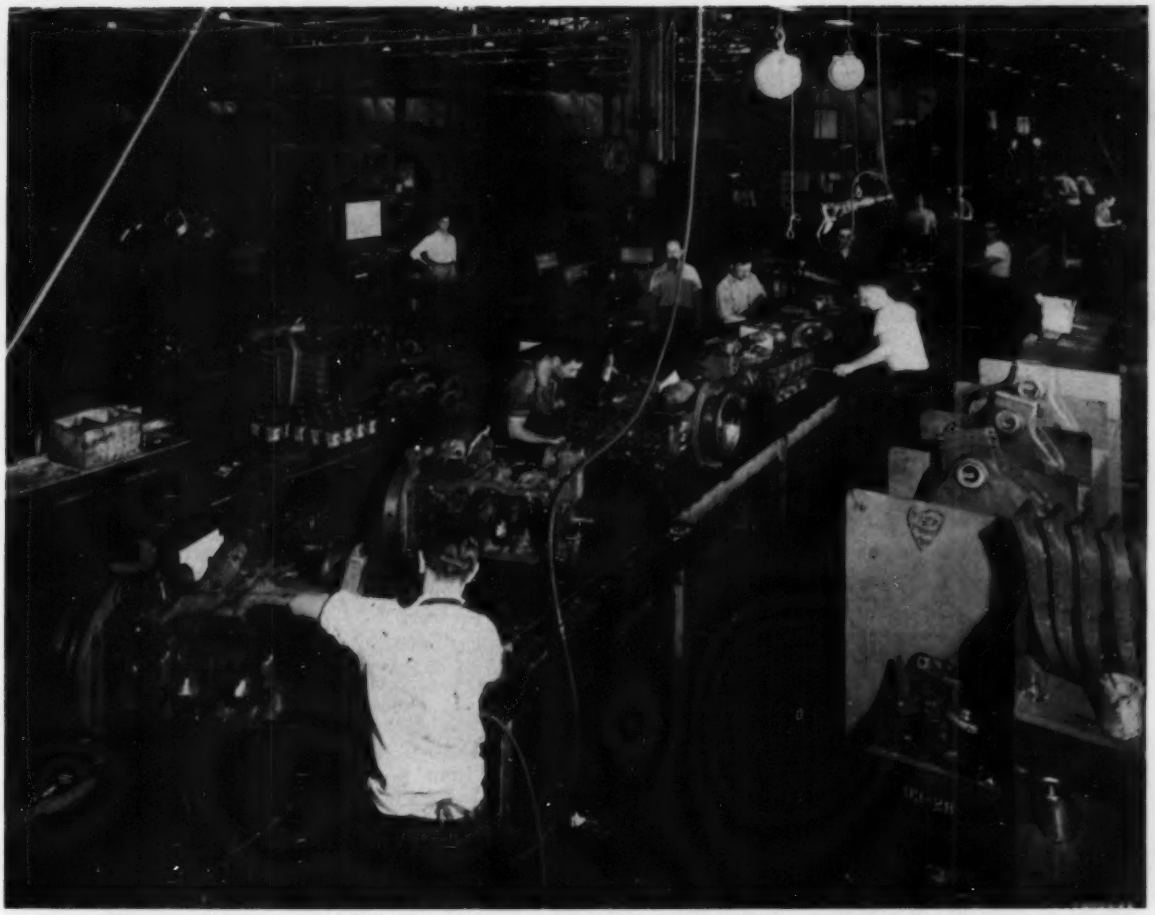
Other characteristics of simulation are:

1. The input variables have an interacting effect on the output of the system.
2. Most of these variables are stochastic in nature. They come from probability distributions and therefore change with time.

The "proof of the pudding" is

IBM Corp.

Industrial engineers use small-scale computers to solve problems of operations research.



Job shops are simulated by industrial engineers using operations research techniques.

the excellent record achieved by users of simulation. United Air Lines reports success with its airport station model, General Electric Co. with a production control model, IBM with a modular system production area, and the Port of New York Authority with simulated peak hour operations.

The list is long and is getting longer every year, especially since many companies are now programming computers for simulation exercises. Once the mathematical model has been established and programmed, the engineer merely has to provide input data to the computer in order to get the results he seeks. This use of the computer frees the simulation engineer for other work.

In addition to its use in the study of complex operating systems, simulation is also used to train people in the operation of complicated tasks and to gain acceptance of proposals through the better understanding of how a system works.

The evidence is clear that simulation is a powerful tool which can immensely improve the quality of understanding in the search for new and less costly systems of operation. It is hoped that more and more industrial engineers will delve into the workings of this tool and find applications for it.

Linear Programming

Not the least of the industrial engineer's problems is that of allocation or assignment. This type of problem arises when:

1. There are a number of tasks to be carried out and there are alternative ways of doing them.
2. Facilities are not available for carrying out each task in the most effective way.

Professor Merrill Flood of the University of Michigan posed the following assignment problem:

Suppose an airline has five planes at a certain airfield. Each day any one of the airline's five planes is capable of flying on any one of the five separate flights. While the fare charged for each flight is fixed no matter what plane flies, the cost of flying the company's five planes varies because the planes vary as to their age and size. The owner of the airline would like to assign planes to the five flights so that the sum of costs is minimized.

The costs of different planes flying to different locations is as follows:

Destination	1	2	3	4	5
Aircraft No.					
1	300	500	320	436	502
2	500	350	635	540	320
3	310	535	250	370	195
4	250	180	110	270	190
5	560	370	250	345	460

Obviously plane number four would be the cheapest to operate on all five flights, but it can only fly one per day.

This problem might be solved,

with the consumption of a great deal of time, by trial and error methods (the reader is invited to try his hand. The correct answer appears at the end of the article).[5] However, Professor Flood has devised a somewhat lengthy, but simple technique for solving it using linear programming. This detailed method can be found in reference 8 of the bibliography.

Three powerful tools of operations research have been presented. A knowledge of these techniques can prove to be a valuable asset to the young engineer first entering the industrial engineering field. In addition, a unique opportunity exists when an engineer couples a knowledge of these techniques with a strong background in computer applications.

For those engineers who went to school before O.R. techniques were refined, one industrial engineer who is acquiring a grasp of O.R. had the following advice:

"Since it is obvious that the character of industrial engineering must necessarily change from a general rule of thumb profession to a rather sophisticated discipline, how does this affect practitioners like myself who went to school before there was such a thing as operations research?

There are three alternatives:

(1) Fight the trend
(2) Be passive
(3) Rekindle long-forgotten study habits and begin to delve into the mysteries of O.R.

The last is by far the hardest of the three, but seems to be the only logical choice.

What can you expect from the first faltering steps in O.R.? Well, for one thing you will find yourself going up many blind alleys. This may be frustrating, but not a waste of time, since you will learn something of the nature of the problem from each wrong turn. The all-inclusive character of O.R. will require the collection of much more data than is required for conventional analysis, and very often the nature of the data itself will make the solution obvious. As you proceed through a problem you will have to do much research and study, and, as a result the first studies will require time.

One of the dangers of O.R. is that during the course of studying a particular technique, the logic and practicality of approach is usually very impressive, and there is a tendency to run madly around the plant with a solution looking for a problem. This approach invariably leads to faulty applications and disastrous results.

The road will not be an easy or a short one, but it will result in more objective and quantitative analysis of industrial engineering problems.[6]

Footnotes

[1] *International Business Machines Corporation.*

[2] Vlahos, Charles J., "Meet Operations Research," *Mill and Factory,* January, 1957

[3] "Queuing," E. V. Krick, Cornell Univ.

[4] Ibid

[5]

Flight

Aircraft	*No.*	*Cost*
1	1	300
2	2	350
3	5	195
4	3	110
5	4	345
		1300 minimum cost

[6] Robert F. Chipak, International Business Machines Corporation, Endicott, New York

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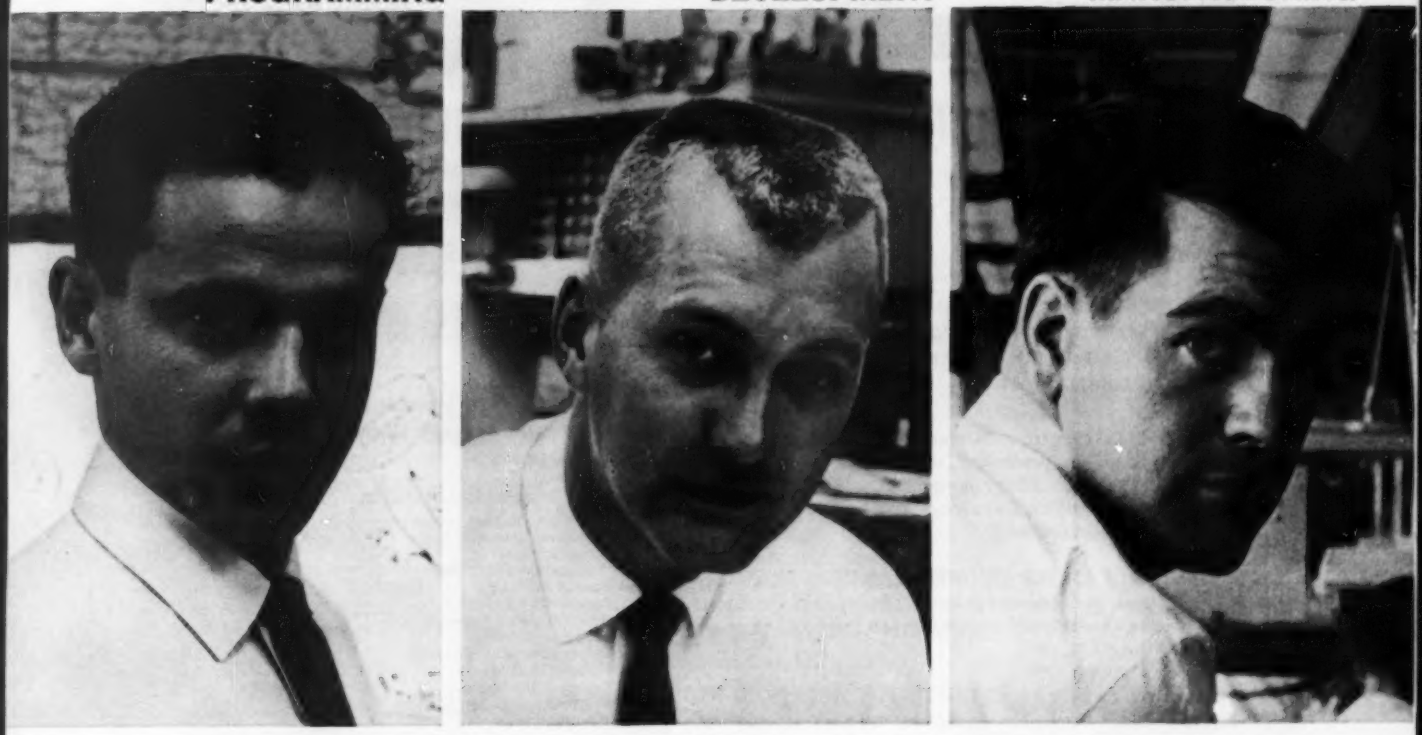


Subsequent advertisements will define the roles played by these young engineers in the creation of data systems at IBM.

Faculty Profile . . .

PROFESSOR ORVAL C. FRENCH

by Thomas H. Wickham, AgE '62

On the Agriculture campus, the Department of Agricultural Engineering is headed by Professor Orval C. French, to whom belongs the credit for establishing the five year professional agricultural engineering program at Cornell. From his consistent dedication has arisen what is now reputed to be the best department of its kind in the nation.

Professor French was born on a livestock farm in Kansas fifty-two years ago. From nearby Kansas State College he earned his B.S. and M.S. in agricultural engineering. For six months he worked alone as the agricultural engineer in a Kansas City boiler plate engineering firm, and here he first appreciated the need for more agriculturally-oriented engineers.

In 1931 he took up part time studies at the University of California and simultaneously did teaching and research. For more than ten years on the coast Professor French worked with some of agriculture's and engineering's most well known men. One of these was Dr. H. B. Walker, who once suggested that he take an administrative agricultural engineering position at a university in order to further this new type of engineering. This he did, reluctantly at first, knowing that only through his students would he be able to accomplish the engineering projects he had planned himself.

In 1947 he came to Cornell with one particular hope: to offer a professional engineering curriculum to agriculture students. At that time agricultural engineering consisted of welding courses, farm mechanics, and other applied subjects spread out among six different buildings. Professor French centralized the department somewhat, and he helped considerably in planning the new Riley-Robb agricultural engineering building. This building now houses over one-half million dollars worth of equipment, more than is owned by any other similar department in the country.

As head of the department, he proposed a five year program. After meeting extensively with several committees, the faculty approved his proposals in late 1952, and the first five students were admitted in the fall of 1953. These students followed a schedule similar to the mechanical engineer's, except that at least one agriculture course was specified each term. The students were enrolled in the agriculture college for the first four years, and in the engineering college for the fifth year. They received Bachelor of Agricultural Engineering degrees from the engineering school. The program was to be financed by the State University of New York, but each student had to pay for his out-of-college courses, which were extensive in number. Finally, the program was to be jointly administered by four professors from each of the two colleges, with Professor French as chairman.

Professor French has a large number of professional engineering associates with whom he meets regularly. The benefits are twofold: 1. Deficiencies in the program, as seen by industry, may be brought to the department's attention and remedied, and 2. Occupational opportunities for graduates are maintained. He has personally arranged positions in industry for a number of his students. This he considers second only to his teaching administration in importance.

Photo Science

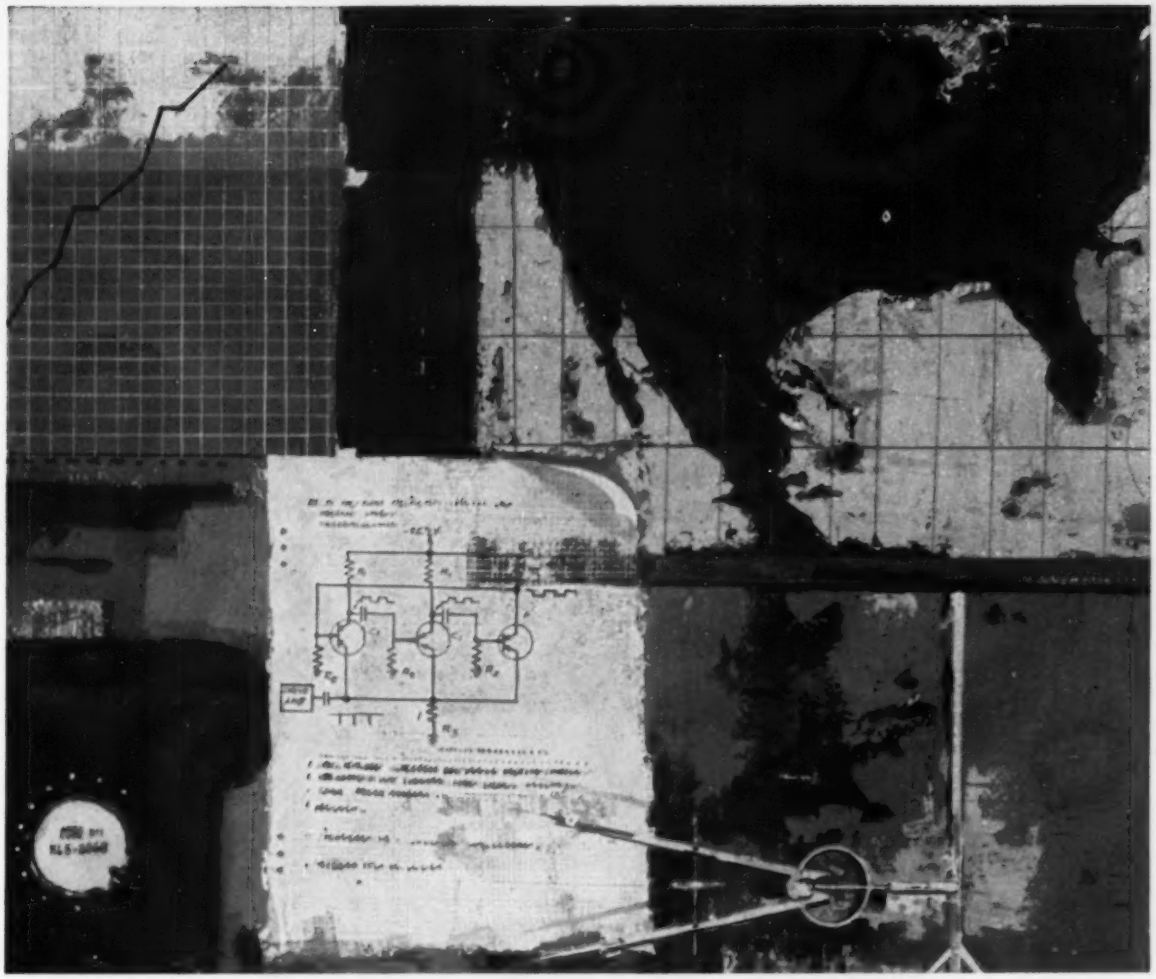
Orval C. French

Professor French also assumes the responsibility of administering research programs. Many firms seek the advice of the agricultural engineering department regarding water control, machine design and many other matters. Because of all of these requests, the department maintains one of the more active research centers of the University.

In 1958 Professor French volunteered to help in the rehabilitation of the University of the Philippine Islands. Cornell has an agreement under the International Cooperative Association of the Point Four Program by which one agricultural engineering staff member is sent each year to help this university become self administering. In the Philippines Professor French was able to teach, a pleasure which he chose to forego at Cornell in favor of administration.

Now back at Ithaca, Professor French teaches only several seminar courses during the Cornell summer session.

By this June approximately twenty-five students will have graduated from Cornell's five year agricultural engineering program. Due to his personal interest in these students, Professor French has known and helped each one, from his freshman year until graduation, and then in industry. Many of these young men were "good" students throughout their undergraduate years, but some varied in their accomplishments. Nothing in his work gives Professor French as much gratification as seeing mediocre students suddenly take on enough interest to excel in their work. He has helped many such students.



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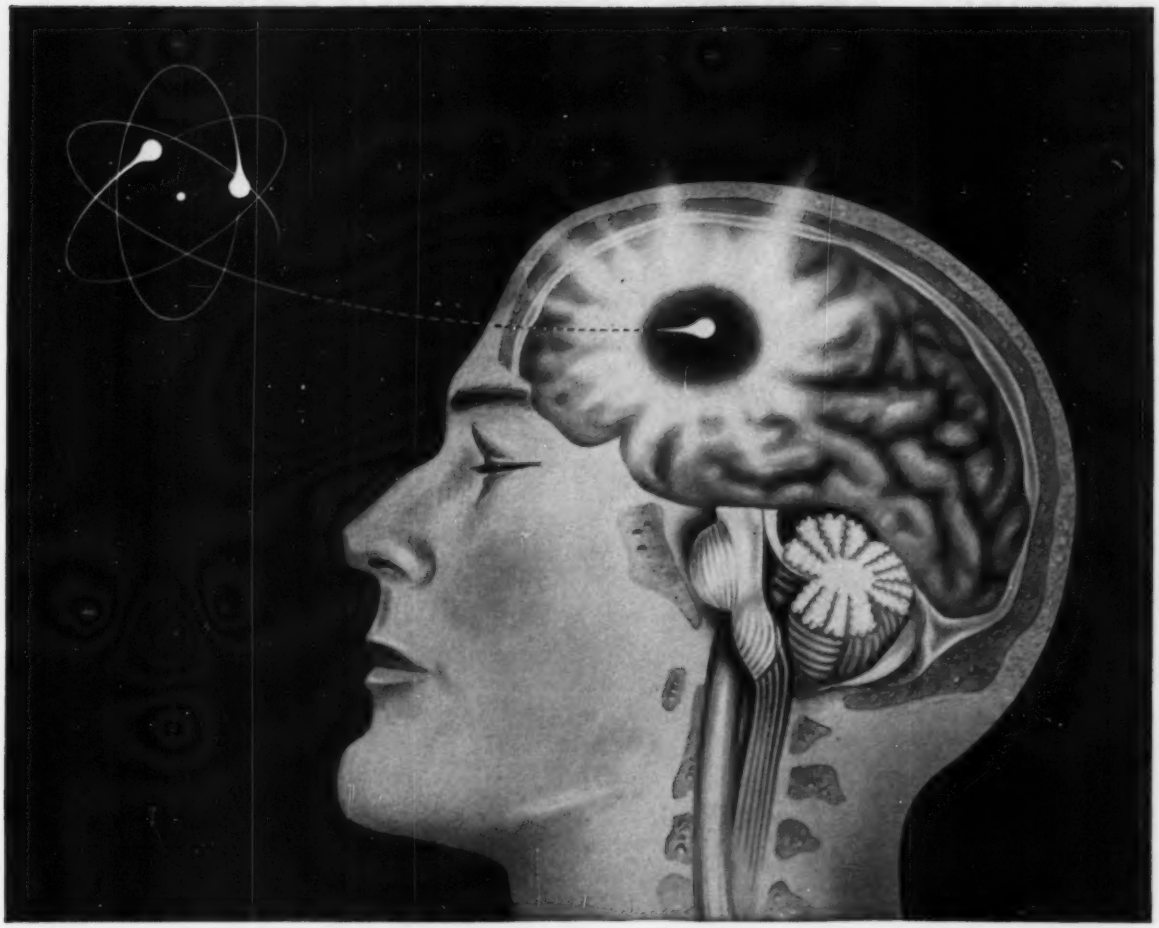

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Physicians and scientists working in cancer research at Brookhaven National Laboratory, Upton, N. Y., are probing the use of Boron-10 isotope in treating a common type of brain tumor (glioblastoma multiforme).

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The method. In a technique known as Neutron Capture Therapy, the patient receives an injection of a Boron-10 compound. Cancerous tissue absorbs most of the neutrons.

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Paul O. Gunsalus

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationships between the College and its alumni."

THE PRESIDENT'S LETTER—

As your new Officers and Executive Committee take over for the coming year it is appropriate to outline who the members of the Executive Committee are and what we hope to accomplish during the coming year.

First, as to the membership of the Executive Committee, it includes in addition to the Officers listed above, the three most recent Past Presidents, Walter L. Hardy, Ch.E. '38, Roscoe H. Fuller, M.E. '24, and Stephen D. Teetor, C.E. '43; Committee Chairmen, William M. Leonard, M.E. '24, Roger Broeker, B.M.E. '47, Austin L. Rumsey, C.E. '23, Walter M. Bacon, E.E. '30, Sidney Turkish, E.E. '59, M. D. Morris, C. E. '44; and Engineering School Representatives, William Littlewood, M. E. '20, Wayne E. Kuhn, Ch.E. '30, Daniel M. Lazar, C. E. '29, Thomas W. Hopper, M.E. '29, J. Paul Leinroth, M. E. '12. In addition to these School Representatives there are six more to be appointed at the next Executive Committee meeting to replace those whose term expired in June 1960.

As to the program for the coming year, four main items are concerning us –

1. A Program of Meetings in New York and in each of the Branch cities that will provide both fellowship and stimulation. Meetings have been held in New York, Chicago, and Boston, as well as an Executive Committee meeting in Ithaca. On November 30, there will be a Dinner Meeting at the Engineers' Club in New York City. It will be held in conjunction with the 1960 Winter Annual Meeting of the A.S.M.E.

2. Increase Memberships. We have about 3200 members out of an Alumni body of 20,000. While this is good, it could be much better.

3. Increased activity in Secondary School work to insure that adequate numbers of qualified embryo engineers are directed towards Cornell. We have a fine new physical plant and an outstanding faculty. We need to keep them both fully occupied.

4. Develop a closer working relationship between the Society and the College of Engineering. To this end, we scheduled a meeting of the Executive Committee in Ithaca on September 30–October 1. This permitted the participation of the Dean, Assistant Deans and the School Directors, who are honorary officers of the Society. A Reception for the Faculty of the College of Engineering was held on Friday, night, September 30, which permitted the Ithaca members of the Society, the Faculty and the Executive Committee members to really get acquainted.

Your officers hope that you will all join in to make this a banner year of accomplishment. Begin by sending in your dues, if you haven't already done so. Then participate in the meetings and bring along a prospective member.

I plan to use this monthly letter to keep the Membership advised of the activities of the Society and its Members. It will be much more interesting if it reflects what you are doing. Please let me hear from you.

PAUL O. GUNSALUS

ALUMNI ENGINEERS

R. David Thomas, Jr., ChemE '37, of the Arcos Corporation, has been elected President of the American Welding Society. The new President took office June 1 and during the 1960–1961 fiscal year will direct the Society's many activities devoted to advancing the art and science of welding.

Dave Thomas has been an active member of the AWS for many years. He is a past chairman of the Philadelphia Section, Chairman of many important AWS technical committees, and has taught a number of courses at Temple University and Drexel Institute of Technology. Mr. Thomas was elected First Vice-President of the Society at the 1959 Annual Meeting held at Chicago, Illinois. In 1958 he received the Miller Medal, one of the highest honors conferred by the American Welding Society.

Don E. Sweeney, ChemE '39, has joined Texaco as an Associate Chemical Engineer.

Mr. Sweeney was awarded his Master of Science degree in Chemical Engineering at the University in February, 1960. He began his professional career at Texaco's Port Arthur-Port Neches, Texas,

R. D. Thomas Jr.

Research Laboratories in June of 1959 and returned to Cornell in September to obtain his MS degree. He will be engaged in research work leading to the development of new and improved petroleum products and refining processes.

George B. Catlin, BEE '25, Detroit Edison electrical engineer and industrial power specialist, has been named Director of Area Development for the company.

The new divisional director joined Detroit Edison in 1936 after service with Michigan Bell

George B. Catlin

and Ford Motor Company.

In 1952 he was placed on special assignment to Michigan's Emergency Defense Contracts Committee, working both in Detroit and with the U.S. Defense Production Administration in Washington, D.C. Since 1953, he has been Senior Engineer in the company's Industrial Sales Division, with responsibility for all major industrial power accounts throughout the area served by Detroit Edison.

Catlin is active in the affairs of the Association of Iron and Steel Engineers and in other industrial groups.

Albert Deermont, CE '09, was chosen by the Kiwanis Club of Chipley, Fla. as the Chipley citizen to be honored this year. A civic dinner was held in his honor at which the Cornell colors and music were used extensively and to which all surviving members of his Engineering Class were invited. Deermont, a former mayor of Chipley and a past president of the Kiwanis Club, is president of the construction firm Coggin & Deermont. Deermont did much of the planning for many of the city's streets and the sewer system. He was instrumental in obtaining a much-needed hospital for the county and was the first chairman of its board of trustees. He is a past president of the Florida Road Building Association.

Paul L. Gillan

The appointment of **Paul L. Gillan, BEE '23, MEE '25,** as Special Assistant to Vice President-Engineering, Mack Trucks, Inc., was announced recently.

Mr. Gillan's association with the automobile industry started in 1925 with American LaFrance Engine Co., where he was chief draftsman, following his graduation from the University. Before joining Mack, he had served White Motor Company for 16 years in various capacities, ranging from engine engineer to chief engineer.

Herbert H. Peckham, ChemE '33, has been appointed division industrial engineer of the General

Chemical Division of Allied Chemical Corp. A General Chemical employee for twenty-six years, he will direct industrial engineering activities of its forty producing plants across the country.

J. Bolling Sullivan, Jr., ChemE '36, has recently been elected vice-president of the Rust Engineering Company of Birmingham, Alabama. In 1953 he joined Rust as a project manager, being especially active in the paper, synthetic fiber and chemical industries. Previously Sullivan had been with the Celanise Corporation of America for seventeen years.

William Littlewood, ME '20, an Alumni Trustee since 1955, is seeking re-election. He is vice-president of equipment research of American Airlines and a director of the Cornell Aeronautical Laboratory. He is internationally recognized for his contributions to the development of commercial airplanes and has been a consultant on aeronautics to government agencies. His honors include the Wright Brothers and Guggenheim Aeronautical Medals and Flight Safety Foundation Award. President of the Cornell Society of Engineers, he is also a member of the aeronautical visiting committee of MIT and the aeronautical advisory committee of Princeton. He taught physics, mechanics and machine design as a senior, received the Sibley Prize for two years, and was president of Tau Beta Pi.

R. A. Woodle, ChemE '43, a Texaco technical employee, is a patentee of a recently issued U.S. Patent covering improvements in manufacture of alkylated aromatic hydrocarbons.

Mr. Woodle joined Texaco as a Chemical Engineer in the Port Arthur, Texas, Research Laboratory. He has held a succession of assignments and is now Supervisor of Lubricants Research.

He is a member of the American Chemical Society and is the author of several technical papers. He holds other patents in the field of petroleum technology.

Henry C. Boschen, ME '28, has recently been elected president of Raymond International, Inc. Mr. Boschen joined the firm, owned by Maxwell Upson, thirty-two years ago.

Jack Scheinuk, BCE '58, has announced the opening of an office, Insure-All Incorporated, in New Orleans. Mr. Scheinuk was formerly Vice-president of the Hartwig Moss Insurance Agency, Ltd.

Nicholas Duda, Jr., has been appointed Assistant Supervisor of Labor Relations at the Pittsburgh Works of Jones & Laughlin Steel Corporation.

Mr. Duda, who formerly was a Staff Assistant in the Department, has been a J&L employee at the Pittsburgh Works since June, 1955, when he joined J&L as an Industrial Relations Trainee. He was named a Staff Assistant in the Labor Relations Department upon completion of his training in 1956.

COLLEGE NEWS

CARPENTER DONATES TO BUSINESS SCHOOL PROJECT

The University plans to erect a new $1,500,000 building for its Graduate School of Business and Public Administration and has received substantial gifts toward its construction.

The new building will bring the school under one roof, permit expansion of its student body, and provide facilities for intensified study, research, and special training programs, according to C. Stewart Sheppard, dean.

Walter S. Carpenter, Jr., Chairman of the Board of the E. I. du Pont de Nemours Company, has given $340,000 to the project, and a foundation with which he is associated has donated an additional $417,600.

It is hoped that construction will start early next year, and that the building will be ready for occupancy in September 1962.

CHEM E'S VIEWS AIRED IN LIFE MAGAZINE

The opinions of Kenneth Alan Collins, ChemE '63, on the topic "America's national purpose" were published in the July 11 issue of *Life Magazine*. They were included as part of an article entitled "Nationwide Response To National Purpose." The article reviewed reactions to the magazine's national purpose articles, one of which was contributed by University Professor Clinton Rossiter.

COMPUTER BUSINESS GAME HIGHLIGHTS IE SEMINAR

Great chunks of facts and figures simulating the operation of four industrial firms over a 12 month period were fed into a data processing system at Cornell which not only did the statistical analysis, but also arrived at, in about two hours, the decisions usually made by top management in a year.

Four imaginary companies were used to illustrate business failure and success for the benefit of 200 top business and industrial executives attending the Annual Cornell Industrial Engineering Seminar, June 14–17.

The companies competed with each other for the sales of three products in a common market, and each game was played in terms of quarters of a year. According to the rules, each team was allowed a maximum of three-quarters of an hour (the decision period) to plan the first quarter, and one-half an hour for each quarter year thereafter.

Prior to the start of the game, each team established the key management positions of president, comptroller, production manager and sales manager—each team having a maximum of six members.

As in real business life, it was assumed that the president had the ultimate authority in decision making and the "referee" communicated with him in decision matters. Each company was provided with a referee, who answered questions regarding the rules of the game, and collected and delivered the decision sheets.

The results of the company's quarterly plan made during the decision period were recorded on a "decision sheet." This sheet was given to the referee at the designated time at the end of the decision period. Failure to have the information when required resulted in a loss of 50 per cent of the sales normally gained for that period – a penalty executives do not have to face in real business life.

After submitting the decision sheet each company continued to analyze its operations. The results of the quarter were compiled on the decision sheet by the referee and returned to the company within a scant 10 minutes, leaving 20 minutes to finish the next decision period.

At the end of the game the companies were evaluated on the basis of profit and loss for the ensuing period, cash position shown by the final quarterly decision sheet, balance sheet as of the last quarter, and the per cent of market gained by each company for each quarter.

The purpose of the game was to show the top executives that by translating business problems into the machine's language they could save much time and effort.

BURROUGHS 220 COMPUTER NOW OFFICIALLY IN OPERATION

The dedication of a new quarter-million dollar Burroughs 220 computer at the University's Computing Center featured "games" taught the mechanical brain by a group of Cornell students.

The Burroughs 220, a new unit with a paper tape photo reader capable of reading 1,000 alphanumeric words per second, played tic-tac-toe, staged a turtle race, and recounted the weather for any day between January 1, 1926, to December 31, 1956, to members of the faculty and administration attending the ceremony.

After entering the day, month and year by pressing buttons, the machine's "memory" came up unerringly with the maximum and minimum temperatures of any one day, as well as the precipitation or snowfall, all in about five seconds time.

The dedication of the new computer, one of the first two Burroughs 220s to be installed at a university, gives the University excellent facilities. Other machines in the Cornell Computing Center in Rand Hall, and access to a $2 million machine at Cornell Aeronautical Laboratory, Buffalo, give the University outstanding facilities for speeding up scientific and engineering research. Richard C. Lesser is director of the Computing Center at the University.

The advantage of the Burroughs 220 can be illustrated by the work it eliminates. For example: A three-inch metal cube at 500 degrees centigrade immersed in water at zero degrees would require 30 hours of mathematical computation per minute of cooling to chart temperature progress mathematically before its temperature at the core dropped to that of the water. But using the Burroughs 220, it would require just 12 seconds to do the same amount of calculation.

Although it costs $150 an hour for various University departments to use the Burroughs 220, graduate students and others pursuing legitimate research projects are permitted to use it free of charge. The Computing Center usually has a waiting list, and quite often those conducting research must use the machines in the Center by night. The key machines in the Center are operating on a 24-hour schedule.

FACULTY CONTRIBUTES TO ENCYCLOPEDIA

Nineteen University faculty members served as contributors or consulting editors for the 15-volume Encyclopedia of Science and Technology, scheduled for publication by McGraw-Hill Book Company this fall.

The Cornell professors were among 2,000 nationally and internationally known authorities in the various scientific and engineering fields chosen to aid in preparing the publication, which is the largest of its kind ever to be published. More than 7,000 articles covering the entire field of science and technology are included.

Members of the engineering school faculty who contributetd included: Henry G. Booker, professor and director, School of Electrical Engineering and assistant director of the Cornell Center for Radiophysics and Space Research; James L. Gregg, professor of metallurgical engineering; Richard M. Phelan, associate professor of machine design; Benjamin M. Siegel, professor of engineering physics; Clesson N. Turner, professor of agricultural engineering; and Charles C. Winding, director of the School of Chemical and Metallurgical Engineering.

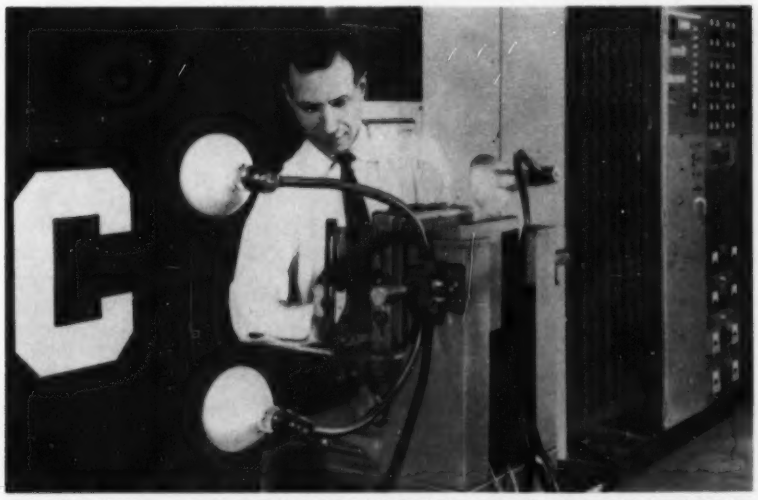
MATERIALS SCIENCE CENTER ESTABLISHED AT CORNELL

The Advanced Research Projects Agency, Department of Defense, disclosed in July that Cornell University, University of Pennsylvania, and Northwestern University have been selected to set up vastly enlarged programs for the expansion of basic research in the science of materials.

Under an unprecedented long-term contract Cornell will receive $6.1 million for the first four years of this program, according to President Deane W. Malott.

The contract provides for interdisciplinary research and graduate student training in materials and will combine the efforts of portions of five departments in two colleges at Cornell. Cornell will organize a Materials Science Center to administer the ARPA contract and to expand basic research and training of Ph. D. research scientists in materials.

"Materials science" is the investigation of physical and chemical processes in solids such as metals. The design of new materials for nuclear reactors, rocket engines, transistors, and other modern devices is based on this kind of research.



Cornell Laboratory engineer adjusts the Mark I Perceptron's photo cell "eye" during a letter recognition training sequence. Note the letter *C*, at left, being shown to the eye. The cabinets to the rear contain the machine's "memory" and "response" units.

Cornell will construct a new $4 million building on its campus within the next three years. The building will house graduate research of the Laboratory of Atomic and Solid State Physics, the administrative offices of the Center, and several of the common technical facilities such as electron microscopes. ARPA will reimburse Cornell for construction costs of this building over a 10-year period after it is occupied.

A substantial part of the $6.1 million contract will go into research equipment, including about $700,000 for individual research projects and $1.2 million for common facilities. The facilities will permit Cornell graduate students and staff to work with the most modern physical, chemical, and metallurgical techniques available.

The basic research scientists who comprise the initial staff of the Center also will have use of a new atomic reactor being built by the University, the new $5.7 million research library nearing completion, and other outstanding facilities already extant at Cornell.

The staff of the ARPA project will be faculty members and research associates already at the University. Additional faculty will be added during the next few years. Teaching and supervision of graduate student research will continue to be the main tasks of these scientists.

Initially, the work of the Laboratory of Atomic and Solid State Physics will comprise the largest part of the Center. This Laboratory, which was organized a year ago, includes faculty and graduate students from the Department of Physics and the Department of Engineering Physics. Later, the greater growth of Metallurgical Engineering and Engineering Mechanics and Materials will make these departments equally important.

Cornell was one of the first universities to enter solid state physics, which generally was not recognized as a distinct science until after World War II. Substantial parts of the work at Cornell are concerned with imperfections, transport processes, magnetic resonances, internal friction, photochemical processes, surface phe-

nomena, ferroelectrics, magnetic phenomena in dilute alloys, optical processes in the far ultraviolet, x-rays, cooperative phenomena, ferromagnetism, many-particle theory, and thermal conductivity.

A second area of emphasis in the Center is chemistry, with about a quarter of the current staff. This research is concerned with electron and x-ray diffraction, inorganic polymers, solid-vapor reactions, electronic processes in oxides, diffusion in polymers, polymers under high pressure, catalysis, photoconductivity, and theoretical physical chemistry.

The third participating field of endeavor is metallurgy, with about a sixth of the staff working on metallurgical science in the fields of intermetallic compounds, freezing, transformations, solid-solution strengthening, nucleation, properties of and phenomena in iron-base alloys, plastic deformation, and fracture.

The fourth substantial research area represented is mechanics and materials, making up a tenth of the staff. Scientists in this field will deal with elastic constants as functions of pressure, ferroelectrics under impulse loading, and diffusion and creep under hydrostatic pressure.

The number of professors in the Center will be increased from about 30 to about 60 in the next 10 years. Four more areas of scientific investigation, namely mathematics, industrial engineering, geology, and electrical engineering, probably will be added to the Center's research program in the near future.

The Cornell Materials Science Center will enable interdisciplinary cooperation in the fields mentioned, and the increased staff will permit the University to train about twice as many Ph. D. scientists in these areas of study. The entire research program conducted by the new Center will be integrated with the program for training graduate students on a personal basis in the use of methods and equipment that will be as modern as that in any industrial laboratory.

One of the objectives of the program is to stimulate the understanding necessary to exploit solid-state physics, chemistry, and physical metallurgy to produce new materials or develop promising new processes. The term "materials research" will be defined broadly—encouraging flexibility in changing research emphasis or entering new fields.

CAL DEVELOPS PATTERN RECOGNITION MACHINE

The Mark I perceptron, an experimental machine which can be trained to automatically identify objects or patterns such as letters of the alphabet, has been developed by Cornell Aeronautical Laboratory Inc.

The Mark I perceptron is a limited capacity version of what eventually may become a family of efficient pattern recognizing machines. It was built to demonstrate and prove the feasibility of the basic perceptron concept which previously had been simulated on high-speed digital computers.

The Mark I is an electromechanical device consisting basically of a "sensory unit" of photo cells which views the pattern shown to the machine, "association units" which contain the machine's memory, and "response units" which visually display the machine's pattern recognition response.

Dr. Frank Rosenblatt originated the perceptron theory and has been in charge of the program since it began in 1956 at CAL.

Dr. Rosenblatt pointed out that "the Mark I system can perform only the simplest pattern recognition tasks and is of scientific interest because of its use of new principles, rather than its present level of performance. The Mark I represents the simplest of the various types of theoretical models we are studying under the perceptron program."

Martin Bingham

Irven Travis, mathematician and chief of computer research at the Burroughs Corp., (seated) demonstrates the new Burroughs 220 computer installed at Cornell University's Computing Center to guests in dedication. Standing left to right in the foreground about Mr. Travis are: Stanford S. Atwood, provost of Cornell; Arthur Grad, National Science Foundation; Richard C. Lesser, Cornell Computing Center director, and James L. Zwingle, Cornell vice president.

Dr. Marshall C. Yovits, Scientific Officer for the perceptron program pointed out "the fundamental significance of machines, like the perceptron, for eventual use in the solution of many scientific, engineering and military problems is recognized by the Services, particularly for the processing of non-numerical information. Although human beings can normally handle these problems readily, machines would have obvious advantages and would supplement existing types of digital computers which fundamentally handle numerical data."

Albert E. Murray, a CAL physicist studying perceptron applications, listed some of the uses for which future perceptrons might be employed.

"Perceptrons might eventually be used in many situations which now require human operators to differentiate between patterns," Murray said. "Such machines would be much larger than the Mark I, although constructed on the same principles. They would have a variety of sensory inputs. For example, they would be able to receive audio as well as visual inputs. They would also contain a greater number of association and response units and, consequently, would be able to perform much more complicated recognition tasks than the Mark I.

"It is possible that in the future a perceptron of much greater capacity than the Mark I could be used to read print of various type faces and to recognize spoken words," he said. "Similar machines might also be used to extract salient features from photographic information."

Considerable research and development effort lies ahead before perceptron-type machines are designed for such applications and it remains to be demonstrated that their use will prove economical, the CAL scientists noted.

CE PROFESSOR NAMED ASSOCIATE ENGINEERING DEAN

Announcement was made in May of the appointment of Professor Gordon P. Fisher of the School of Civil Engineering as associate dean of the College of Engineering at the University.

The new associate dean, a specialist in structural engineering, has been engaged continuously in teaching and research since he came to Cornell. Professor Fisher's research is concerned with laterally-loaded steel columns and with combined bending and torsion of reinforced concrete beams. He currently manages the structural testing facilities at Cornell and is in charge of training all research assistants there.

The new structural model analysis laboratory and much of its equipment, housed in the new civil engineering building at Cornell, is his creation. When completed the laboratory will offer extensive equipment for analysis of structures in both elastic and plastic modes and will include complete shop facilities to support student and faculty research.

Professor Fisher currently teaches graduate courses in advanced structural analysis which for the first time treat in some detail methods of structural analysis for application to digital computers. He also teaches structural design and is collaborating in the writing of a textbook on this subject.

For the past three years Professor Fisher, as consultant on a large atomic power plant now under construction, has been actively engaged in the analysis and design of containment structures for nuclear power reactors. This is a relatively unexplored field of engineering which is concerned mainly with methods to prevent the spread of fission products upon a surrounding community in the unlikely event of a nuclear malfunction or accident.

Professor Fisher came to Cornell in 1948, became an associate professor in 1951 and a professor in 1959. He has worked with the National Advisory Committee for Aeronautics on aircraft structural research, the Maryland State Roads Commission as a bridge designer, and the Pittsburgh-Des Moines Steel Co. as a principal design engineer.

The Professor received his bachelor of engineering degree in 1942 and his doctor of engineering degree in 1948 from The Johns Hopkins University, Baltimore, Maryland.

He is a fellow of the American Society of Civil Engineers and a member of its Committee on Electronic Computation, Structural Division. He is also a member of the American Concrete Institute and chairman of its technical committee on torsion in reinforced concrete, as well as a member of the International Association for Bridge and Structural Engineering. He belongs to Tau Beta Pi and Chi Epsilon, national engineering honoraries, and Sigma Xi Society, honorary research society which was founded at Cornell.

ME SCHOOL AWARDS PRIZES

Marc Fishzohn, ME '60, was the recipient of the 1960 Hamilton Watch Award, given to the senior in the College of Engineering "who has most successfully combined proficiency in his major field of study with achievements either academic, extracurricular, or a combination of both in the social sciences and humanities."

He served on the Planning Board of the Campus Conference on Religion, the Executive Committee of Orientation Counselors, and was the holder of Theta Delta Chi's "Outstanding Senior at Cornell Award." He was president of his fraternity, Sigma Phi, and president of Tau Beta Pi. He is a member of Red Key, Scabbard and Blade, and Quill and Dagger honorary societies on the campus, as well as Pi Tau Sigma and Phi Kappa Phi, national scientific honoraries. He has five Navy ROTC awards, and is the winner of several nation-wide essay contests. He ranked third in his class, and held several scholarships.

Other mechanical engineers receiving awards were Edward J. Ignall and Robert Shaw, Jr., '60, who received Sibley Prizes; Leonard H. Copeland, '60, the Machine Design Award; and Robert Shaw, Jr., the Air Conditioning Award.

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ALLIS-CHALMERS

EXHIBIT CELEBRATES SPERRY CENTENNIAL

by John W. Hughes EP '64

An assemblage of over 150 prominent people was on hand early in the summer for the opening ceremonies of the Sperry Centennial Exhibit at the Smithsonian Institute in Washington, D.C.

Among those present was Commander William R. Anderson, skipper of the nuclear submarine, Nautilus, the first to be guided under the polar ice cap by a Sperry gyrocompass.

Dynamos and Arc Lights

Elmer Ambrose Sperry was born in Cortland, New York, on October 12, 1860. In his boyhood his inventive bent was soon evident. He built windmills, batteries in glass jars, and a tricycle he could ride on the railroad tracks, just ahead of the slow-moving freights. While attending the State Normal School, which was at that time a pioneer in electrical instruction, he visited Cornell University, twenty miles away by horse and buggy.

At nineteen Sperry built an arc light and later a generator at the works of the Cortland Wagon Company, and illuminated the Cortland Christmas festival in 1879. In 1880 he moved to booming Chicago and opened the Sperry Electric Illuminating and Power Company. In addition to the installation of arc lights on several of Chicago's larger streets, he installed a corona of lights on the tower of the Board of Trade Building aggregating over 40,000 candlepower – the highest and most powerful beacon of its time.

Electric Locomotives

After his dynamos had become widespread, and transmission lines had been built, Sperry turned to inventing electrically-operated machines. While on his honeymoon in 1887, Sperry had an invitation to go down into a coal mine. He became interested in the improvement of mining machinery, and within a year had designed the first electric coal punching machine–which later was replaced by his continuous chain cutters.

To haul out the increased coal production of his mining machines, Sperry developed an electric locomotive which could haul 1000 tons a day. This naturally led to the Sperry electric trolley car to which he applied the same electric drive which had been so successful in the electric locomotives (four-wheel trucks, with geared single motor drive.) The Sperry Electric Railway Company was organized in 1890, although the newly formed General Electric Company bought the business and patents in 1894.

The Gyroscope

Sperry's most famous product, and that which is still associated with his name, is the gyroscope. After a rough crossing to Europe in a large passenger liner, he envisioned the use of a gyro-stabilizer for ships.

Sperry developed a gyro-stabilizer for the naval destroyer *Worden* and installed it in 1913. This was followed by many more stabilizers of various sizes, the largest being a three-gyro system for the liner *Conte Di Savoia.*

Another use of the gyro which interested Sperry was the gyrocompass. Due to the extensive amount of metal on the steel battleship, magnetic compasses had proved inaccurate and unreliable. By April 19, 1910, development of his gyro-compass was proceeding so rapidly that Sperry organized the Sperry Gyroscope Company to produce gyroscopes for ships and aeroplanes.

Sperry also developed the most important airplane instrument of its time–the instrument that first made it possible to fly blind at all –the Gyro Turn Indicator–a basic flight instrument still found in every aircraft.

Sperry the Man

Sperry was outwardly an unusually self-confident and optimistic person. He was a prodigious worker and budgeted his time to an exact schedule. He even designed a circular, spiralled slide rule which he could work with one hand while he jotted down his computations with the other. He filled more than 60 notebooks with writing and sketches as ideas occurred to him.

A well tailored, distinguished man, Sperry was noted for his interest in the theater, golf and other sports. Yet his chief love of life was technology and his greatest elation came after a technical triumph.

At all times he displayed those qualities which inevitably lead to success. He was physically and mentally fit, socially persuasive, tenaciously self-confident and, above all, intensely interested in delving into the unknown.

The Sperry News

IN HONOR OF ELMER A. SPERRY — Exhibit, marking the centennial of Dr. Sperry's birth, is displayed at the National Museum Branch, Smithsonian Institution, Washington, D.C. In five parts, the exhibit covers much of Dr. Sperry's personal Achievements and correspondence with famous people. Other sections feature Sperry Gyroscope Company's vast contributions on land, sea, in the air, and in space.

TECHNIBRIEFS

ONE-INCH FALL FATAL

A missile may fail in its mission because a worker on the assembly line let a part drop one inch on a workbench, *American Machinist/Metalworking Manufacturing*, reports. Tests show that when instruments fall one-to-three inches, forces up to 20 times those of gravity strike them, and the results are sometimes disastrous.

OTHER PUBLICATIONS PUSHBUTTON HIGHWAY AID

Pushbutton emergency call boxes, powered by the sun, soon may be dotting the nation's highways, reveals *Product Engineering*. The transmitter, designed for mounting on poles, has pushbuttons for summoning fire, police, ambulance or service help. The battery pack is powered by solar energy, trapped through five silicon cells atop the unit.

ALUMINUM FROM COAL

If an Ohio coal mine's plans to build an aluminum sulfate plant materialize, the North American continent will gain an important new source of aluminum, declares *Chemical Engineering*. Along with coal, the mine each year produces millions of tons of 20–25 per cent alumina-bearing shale that have been previously discarded as waste.

THRUST REVERSER PERMITS SHORTER LANDING STRIPS

Rohr Aircraft Corporation, Chula Vista, California, has developed a thrust reverser for Lockheed's JetStar. Thus, this new executive jet can land at airports that have relatively short landing strips.

This, in effect, enhances the value of jet travel for industry executives since, in many instances, it enables them to land closer to their destination rather than seek out a large metropolitan airport. Distance and time between airport and appointment are reduced.

Reversal of a jet engine's thrust—which could loosely be compared to an automobile brake—is obtained by closing across the path of the exhaust two clamshell doors which, when closed, divert the thrust upward and downward at a forward angle. The result is a substantial slowing-down of a plane without a marked cutback in engine power, permitting a jet to land on a shorter runway.

MECHANICAL FISH STUDIED

Scientists are using mechanical fish to find out why fish move through the water ten to twelve times more efficiently than anything man can build, *Control Engineering* reports. The mechanisms simulate movements of fish under various wave conditions.

ATOMIC JEWELRY

Gadgets that measure the radiation exposure of atomic workers look strangely like items of personal jewelry, reports *Chemical Engineering*. Beta-gamma dosimeter tubes are clipped into workers' pockets like fountain pens, film badges clip on to lapels like brooches, and jet-like black finger rings measure radiation dosage to the hands.

WESTINGHOUSE BUILDS LARGEST THERMOELECTRIC POWER GENERATOR

Westinghouse has announced the successful development for the Bureau of Ships, U.S. Navy, of the most powerful thermoelectric generator ever built. The generator delivers five kilowatts of electric power by the direct conversion, without major moving parts, of heat into electricity. It is 50 times more powerful than any previously described thermoelectric power plant.

The new generator is an experimental unit intended for evaluation of power generating materials and fabrication techniques which have been produced under a Navy-sponsored thermoelectric materials research program. New materials developed by this program in the last three years have tripled the efficiency with which heat may be directly converted to electricity. This high rate of progress supports Navy hopes for an early achievement of practical thermoelectric generators of considerably larger size.

RADIOACTIVE TRITIUM USED TO STUDY CHEMICAL REACTIONS

A radioactive ball, smaller than the head of a pin, has made it possible to trap and study atoms that are responsible for triggering most chemical reactions, including those involving living cells, a Ford Motor Company scientist announced recently.

The radioactive element used in the new process is tritium, similar to hydrogen, but heavier and having a different nucleus. Changed from its natural gaseous form into a solid by immersion in liquid helium at $-450°$ F., the tritium molecule decomposes, with one of its two atoms turning into helium, the other becoming a free radical. As free radicals are extremely reactive and combine readily with everything with which they come into contact, the super-cold temperature is necessary to slow down this tendency to recombine and permits them to be studied with magnetic equipment.

By applying microwaves of uniform frequency but varying magnetic fields to single atoms of tritium, the nature and the magnetic qualities of the substance can be determined by noting the amount of microwave energy absorbed. An atom is, in effect, a bar magnet due to the motion of electrons; similarly is the atom's nucleus an even smaller bar magnet due to the action of nucleons. By using microwaves to incline the axes of these magnets, a process known as paramagnetic resonance, the differences between tritium and hydrogen are readily apparent when their nuclear magnets are compared, and the differences between the nuclear and electron magnets in the tritium atom also can be noted. Measurement of the

wavelengths yields additional data about the impurity of the atom.

This is the first time tritium in a solid form has been studied by paramagnetic resonance. Radioactive materials previously have been used as tracer elements in scientific research, but with a distinct difference from free radical work.

NEW COMPUTER WILL GUIDE TACTICAL MISSILES

Greatly increased capacity, scope, and performance in airborne digital computers has become possible with the introduction of a new instrument developed by Librascope Division, General Precision, Inc.

The LIBRAGAL will be used in the guidance system of a tactical missile. Contract specifications call for a program which will evaluate the feasibility of a target, control the countdown, raise the launcher, fire the missile, provide flight navigation and guidance and, finally, detonate the missile on target.

Within the general-purpose element, the LIBRAGAL utilizes what are believed to be the most advanced air-cooled sandwich-type logic cards ever developed. Use of this type of plug-in card made it possible to contour the computer package to fit the curved shape of the interior surface of the missile shell. With this shape, the computer occupies a 60-degree sector of the missile's circumference, extending to within approximately 6 inches of the central axis of the missile and giving the computer a cross section shaped roughly like a keystone.

Components for the general-purpose computer are all standard production items. Capability and reliability were chief factors in the selection of diodes, transistors, transformers, and other elements. Microminiature elements which had not been thoroughly tested for operational life and reliability were bypassed.

LIGHTWEIGHT MIRRORS FOR SPACE TELESCOPE

New lightweight mirrors of fused silica have been developed for use in missile, satellite, and airborne telescope systems.

Corning Glass Works is producing mirror blanks made by an unusual sandwich construction that reduces size and weight of mounting and auxiliary equipment, vital considerations in aerospace telescopes.

Because they require less elaborate supporting structures, these reflective disks also offer an advantage in ground observatory installations.

The mirror blanks consist of two fused silica plates separated by walls or tubes of the same high-purity glass. The ribs are permanently sealed to each plate under intense heat.

With this type of construction, mirror weight can be reduced to half that of a solid disk with equal surface area.

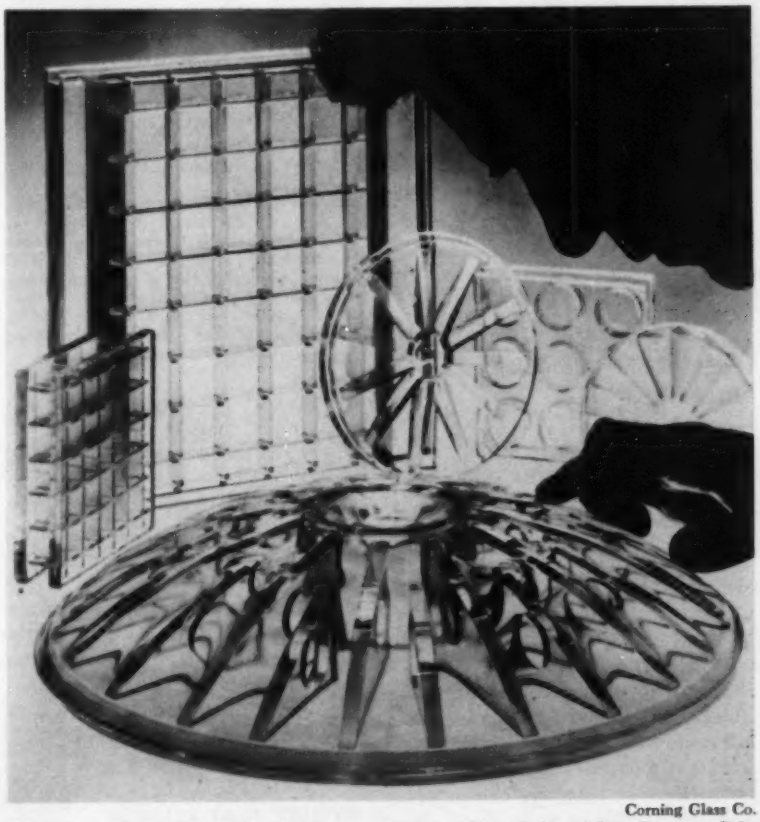
The near-zero thermal expansion of fused silica means the mirrors will retain their shape under sudden and extreme temperature changes. The ribs help maintain rigidity. These qualities assure distortion-free images even in hostile environments.

TV CAMERA DEVELOPED FOR RUGGED ENVIRONMENTS

Development of the world's most rugged television camera, built to withstand weather, shock, vibration, noise, salt spray, dust, and other extremes of environment without an auxiliary protective housing has been announced by Dage Television Division of Thompson Ramo Wooldridge Inc.

Engineered to military requirements for use in all types and phases of missile and aircraft programs, this instrumentation camera is applicable for wide industrial usage in mines, chemical plants, oil refineries, powder plants and other areas where a high performance, rugged camera is needed.

The system is totally transistorized, eliminating microphonics and erratic operation often caused by high acoustical noise levels, vibration and other environmental circumstances. It employs modular construction, using plug-in transistorized printed circuit mod-



Corning Glass Co.

Made by an unusual sandwich-type construction, these lightweight telescope disks have been developed by Corning Glass Works for use in missiles, satellites and aircraft. The mirrors consist of two plates of fused silica, held apart by ribs or tubes of the same high purity material. This weight-saving construction makes the mirrors light enough for compact telescopes needed in outer space photography.

ules, each representing a particular function of the camera.

The simple straightforward concept of this equipment lends itself to further design of transitorized systems, and special television equipment to meet requirements of the military and industry with problems of rugged environment instrumentation.

QUARTZ CELL WILL MEASURE ROCKET THRUSTS

A new 510 Quartz Load Cell, featuring high capacity, excellent repeatability, and utmost rigidity in a small package, has just been introduced by Kistler Instrument Corp., Tonawanda, N.Y.

Although basically a dynamic instrument for measuring changes in load, accurate static measurements are possible over a few minutes time interval, making it ideal for rocket engine thrust measurements.

Measuring less than ¾" diameter by ¾" long, the 510 deflects less than .001 inch under a rated maximum load of 5000 lbs. One-hundredth of a pound variation in load can be measured at any level from 0 to 5000 lbs.

Static pressure signals, caused by loads existing before a measurement, can be eliminated by momentarily grounding the signal lead. Basically designed for compressive forces, the 510 will also measure very small tensile forces, as it has a preload on the crystal. With a special tension adaptor, however, it can be converted readily for measuring large tensile forces.

FAST MAGNETIC SWITCH DECREASES ACTUATION TIME

A team of engineers at Bell Telephone Laboratories has invented a very fast electromechanical switch called the "ferreed." It utilizes a new technique for actuation which is compatible in speed with electronic circuits.

Magnetic materials that can be quickly switched between two alternate states have been widely used as "memories" for storing information in digital computers. The useful output from these elements has generally been limited, however, to electrical signals of a transistory character.

In conventional electromagnetic relays, on the other hand, continuous electrical currents can be used to open and close metallic contacts for extended periods of time, but at speeds limited by the mechanical motion of the moving parts.

The ferreed combines the rapid switching of bistable magnetic material with metallic contacts for output indications that persist as long as desired without further application of power. In several models of the device, a cobalt ferrite has been used as the magnetic material and a glass-sealed magnetic reed switch for the output contacts, hence the name, "ferreed."

In operation, the magnetic material is switched by a magnetomotive force applied, typically, as a five-ampere current pulse in a thirty-turn winding. Control pulses

Bell Telephone Co.

In this two-branch "Ferreed," an electromechanical switch developed at Bell Telephone Labs, the plastic end-pieces magnetically circuits the ferrite bars to the magnetic reed switches. The passage of magnetic flux through the reed switches closes the circuit.

as short as five microseconds will switch the magnetic material, resulting in the passage of magnetic flux through the movable members of the reed switch. Actual closure of the contacts is delayed by inertia of the reeds for several hundred microseconds.

Release of the contacts is brought about by cancellation of the magnetic flux through the reeds, as the result of another five-microsecond switching operation. Opening of the contacts requires less time than the closing operation.

MYSTERY HEAT RESISTOR

An English plastics firm has announced discovery of an unidentified family of polymers that retain their strength at temperatures as high as 1,110 F., according to *Chemical Engineering*. Anything over 500 F. has been considered outstanding for plastics. Applications for the new materials are expected in missiles and high speed aircraft.

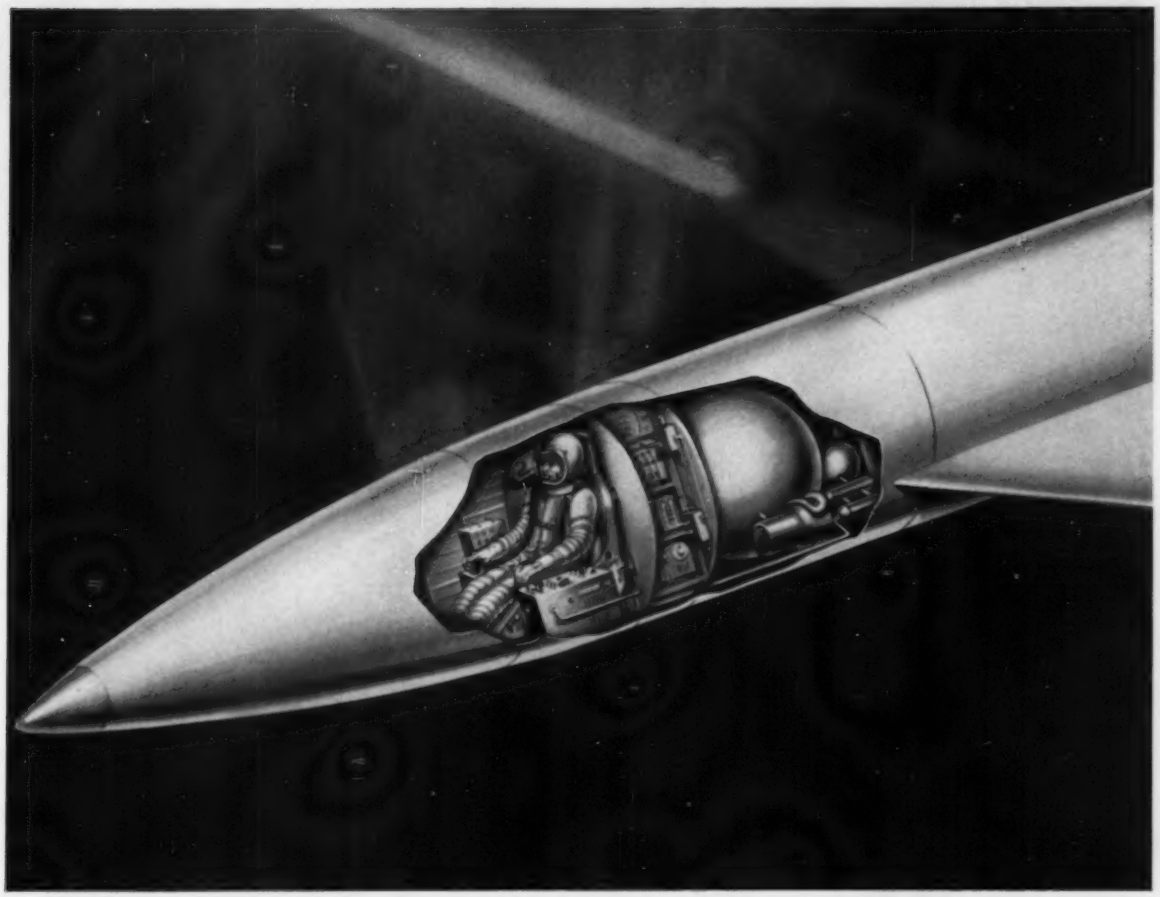
NEW ELECTRONIC TUBE MAKES ELECTRONS VISIBLE

A small electronic tube, developed by scientists at the Westinghouse research laboratories, reaches the near ultimate in the ability to amplify ordinary light. The tube, known as the Astracon, is so sensitive that it makes visible a single electron, released at the tube's input by an individual photon, the smallest unit quantity of light that exists.

The Astracon tube operates upon a unique amplifying principle discovered at the Westinghouse research laboratories five years ago. The image of an object, so dim that it is invisible to the naked eye, is focused by lenses onto a light-sensitive screen, called a photosurface, at the input end of the tube. The individual particles of light, or photons, arriving from the scene strike the surface and eject electrons from it.

Each ejected electron is then accelerated forward by 2000 volts and strikes head-on into a thin two-layer film, only a few millionths of an inch thick. The front surface of the film is aluminum; on its back surface is deposited a slightly thicker layer of an insulating material. When a high-speed electron crashes into the film, it penetrates into the insulator and releases four or five additional electrons. These are accelerated into a second film, or dynode, where the electron multiplication is repeated.

By using five such steps, a single electron is multiplied into about 3000. These are given a final 20,000-volt boost and are aimed into a thin layer of fluorescent material at the output end of the tube. Here they release 20,000 or more photons of visible light. Thus, if the light striking the input photosurface is in the form of a dim, invisible image, the Astracon exactly reproduces that image on its output, only thousands of times brighter.



Forthcoming space exploration will require exotic fuels and new concepts in energy conversion to keep men alive and equipment operating for long periods of time beyond the earth's atmosphere. Advanced hydrogen systems recently developed by The Garrett Corporation have solved this problem of providing the electrical, hydraulic and pneumatic power, plus cooling and heating required aboard a satellite or space capsule during launching, outer space flight and re-entry.

Besides such spacecraft and missile systems, other product areas in which Garrett engineers work include small gas turbine engines, flight data systems for air and underwater use, nuclear and solar power systems, cryogenic systems and controls, and air conditioning and pressurization systems for conventional aircraft and advanced flight vehicles.

Such diversity of interest not only makes work more interesting at Garrett, but gives the engineer an opportunity to increase his knowledge and chances for responsibility and advancement.

An orientation program lasting a period of months is also available for the newly graduated engineer, working on assignments with experienced engineers in laboratory, preliminary design and development projects. In this way his most profitable area of interest can be found.

Should you be interested in a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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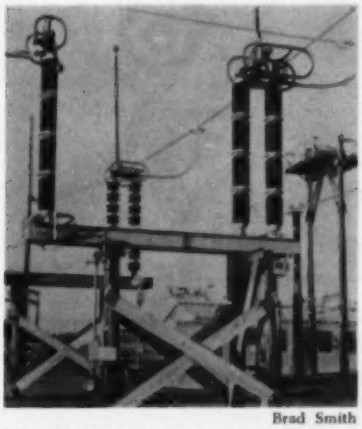
Research at Cornell . . .

PROF. ROSSON HEADS HIGH VOLTAGE LAB

Professor Joseph Rosson, of the School of Electrical Engineering, has been director of the Extra High Voltage Cable Lab at Cornell for the past two years and will continue to direct testing of cables at the lab for the next three years.

Professor Rosson came to Cornell in 1947 as a graduate student and received his MEE in 1950

Professor Rosson has undertaken



Brad Smith

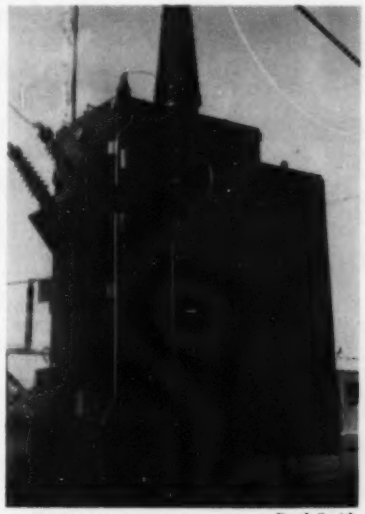
These high voltage terminals are capable of withstanding the 500 KV that is often used to test cables.

various research projects since coming to Cornell. In conjunction with the Cornell Aeronautical Laboratory, Professor Rosson and three associates developed a computer for the Lacrosse missile which processed information from radar and fed the results to the missile. Thinking of his project, Professor Rosson said that the project would "not be possible to do today at the same price" and in the same time. For two years, he was also director of a project for the study of ionospheric refraction.

At present, Professor Rosson is actively engaged as director of a project for the testing of high voltage cables. The project is sponsored by the Association of Edison Illuminating Companies, a group of twenty-four of the largest utility companies in the United States, with the co-operation of the four largest cable companies in the U.S. The studies are for the development of cable transmission systems for the underground transmission of power, with the present anticipation of up to 500 megavolt-amperes. The voltage will range from 350 KV to 500 KV.

This summer a testing and research station, located on Mitchell Street, adjacent to the Cornell campus, was completed at a cost of over one million dollars. The station is capable of handling 500 KV and carries loads in excess of 10,000 kilo-volt amperes. All cable specimens are unique in construction and design. The testing will include dielectric studies and heat flow studies in nonlinear systems. It is expected that study and evaluation will be completed by September, 1963.

Professor Rosson is married and has one child. For relaxation, he likes to go bowling and play golf. While at Cornell, Professor Rosson has taught servo-mechanisms, electrical measurements, and basic electronics. He has represented Cornell at conferences of the AIEE and was a joint representative to the Union of Radio and Scientific Internationale.



Brad Smith

Two specially made Westinghouse transformers supply the high voltage needed for the project.

FIFTY YEARS AGO IN THE ENGINEER

Edited by R. N. Karnes CE '62

During the past summer a number of changes in the curriculum of Sibley College and improvements in the equipment have been carried out, to make more adequate provision for the steadily increasing registration in mechanical engineering.

A forty foot extension was added to the Foundry, making the total working space at present one hundred and eleven by forty feet. Two new hand moulding machines, a core oven and a new lot of shovels were added to the foundry equipment. A new apparatus for starting the fire in the cupola consists of a kerosene tank from which, by means of compressed air, a fine spray of the fuel is forced into the bottom layer of coke. Mr. Vanderhoef is still in charge and looks forward to a busy year.

This year, for the first time, the Sophomore course in mechanics, and the Junior course in hydraulics, will be given under the immediate supervision of Sibley College. Formerly these courses, although a part of the required curriculum, were given in the College of Civil Engineering. The reason for the change is that it is desired to get in closer touch with the students taking these courses, so that the work may be a better antecedent to the more practical ensuing courses. The text books used will be those of Professor Church, as formerly, but the methods of instruction will differ slightly.

A new wood floor has replaced the old cement one in the machine shop, having been laid during the spring and summer. It is very solidly supported by a concrete sub-floor which absorbs the vibrations caused by the machines. The machines themselves have been rearranged so as to get the most possible floor space for the operators. —*The Sibley Journal*, October, 1910.

With this issue the SIBLEY JOURNAL enters upon the twenty-fifth year of its existence as a technical periodical representing the interests of the various branches of engineering in Sibley College. In general the passing of each year has left its mark of betterment and improvement; each succeeding volume has been a step forward. The advance, however, although it has been, except for occasional short periods of dormancy, steady and unbroken, has not kept an even pace with the wonderful progress made by Sibley College itself. The quantity and quality of the material set forth in the pages of the paper to-day, shows but a slight change from the same characteristics in the old *"Crank,"* as the magazine was called about the year 1890. In spite of the marvellous growth of Sibley College, with the accompanying increased body of alumni and undergraduates, there has come no very marked change in the paper which represents that institution. There can be only two rational explanations of such a condition: either that the various succeeding editorial boards have maintained no fixed policy of advancement and betterment from year to year, being content merely to equal the efforts put forth by those in control before them, or that the paper has reached the pinnacle of perfection for the college technical periodical and can be brought no higher. We believe the latter assumption to be wholly incorrect, and feel that with a vigorous determination on the part of each editorial board to foster at least a slight amount of improvement during each succeeding year, the SIBLEY JOURNAL can be made to discover possibilities of becoming one of the best technical periodicals in the country.

It is necessary and highly desirable that the editors of the SIBLEY JOURNAL look to the alumni and faculty of Sibley College for the greater portion of the material which fills its pages. This is necessary in order that the purpose of the paper be fulfilled: to act as a medium for the thoughts and ideas of the men who represent the College. It is desirable because there are in the two bodies mentioned an unlimited number of highly capable and experienced professional men whose writings are eagerly sought by the standard technical magazines. It is the help of these men that can undoubtedly make the SIBLEY JOURNAL one of the foremost of engineering publications, and the present editorial board starts the new year with the fixed policy of engaging the interest and aid of the alumni and faculty of Sibley College with a view to making the JOURNAL a fit representative of one of the finest engineering schools in the world. —*The Sibley Journal*, October, 1910.

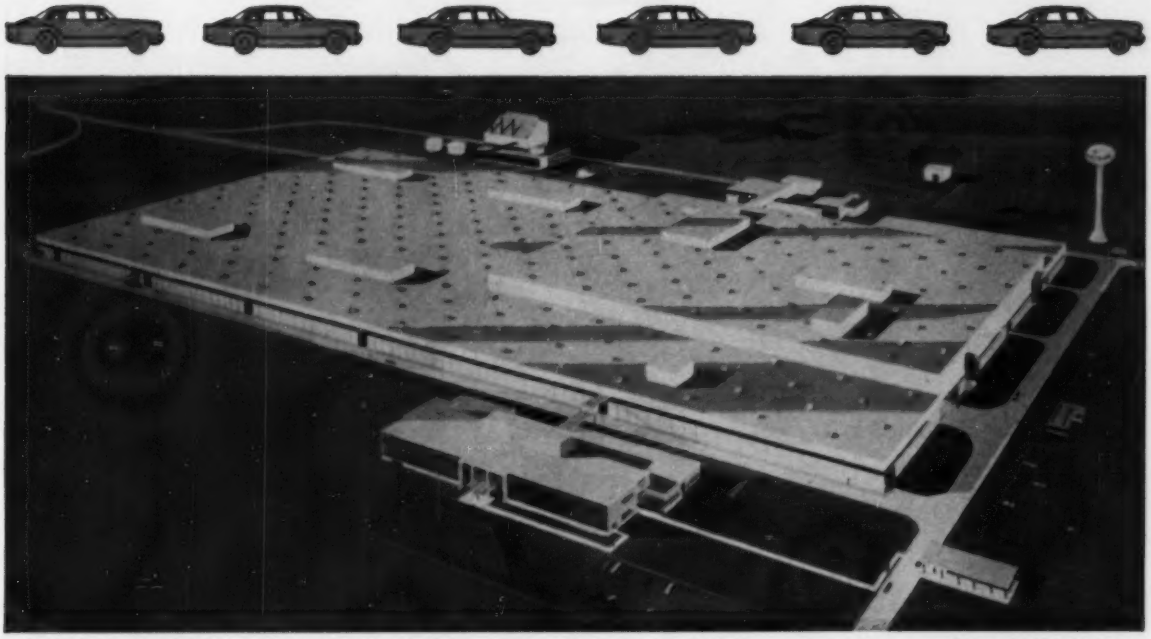
One can scarcely realize that, within the memory of persons now living, the idea of transmitting intelligence electrically by wires was regarded as a chimera. Indeed, the first messages sent from Balti-

more to Washington over the original line, in the construction of which Ezra Cornell was a leading spirit, created no end of astonishment among members of Congress and others. The story of the electric telegraph begins at sea. Mr. Morse first conceived the idea while returning from Havre on the packet ship "Sully," in 1832. At that time the electro-magnet was a scientific novelty, and nobody knew much about its action or possible uses. Mr. Morse, however, had the notion that it could be used in signalling. He was a poor artist, at times reduced almost to poverty, and want of means and of suitable apparatus for experimenting delayed the development of his invention. His application for a patent was made in 1837, but the invention was really conceived several years earlier.

The first public demonstration was made at Morristown, N.J., in January, 1839, over three miles of wire. But, like the telephone in later days, the primitive telegraph was mostly regarded as a scientific toy, and few persons were able to believe that it possessed commercial utility. This state of incredulity is indicated by the attitude of Congress. It was five years later and after repeated failures, when a bill was finally passed appropriating $30,000 for the construction of an experimental telegraph line between Washington and Baltimore, in 1843. The original plan for this line was to lay a lead pipe, containing two insulated wires, in a trench under the surface of the ground. Mr. Cornell devised a plow that operated very successfully in cutting the trench and laying the primitive cable. After about ten miles of construction it was found that the insulation, which was cotton yarn and shellac, was imperfect, and at the same time the financial situation was very critical, as the funds were insufficient to carry out the work as planned, and it became important to stop operations without letting the newspapers know the real reason. The superintendent was equal to the occasion, for he forthwith ran the plow against a stump and wrecked the apparatus. It was supposed that two wires were necessary, the use of the ground to complete a circuit not having been discovered until some time later. Finally the line was completed on poles and opened for operation in May, 1844—*The Sibley Journal*, October, 1910.

Tantalum lamps for street cars have been experimented with extensively by the Chicago Railways Company, according to the *Electrical World*. Regularly operated cars were equipped with tantalum lamps and accurate records kept of the car-miles, lamp-hours, voltage and displacements. Various forms of frosted globes were tried but were discarded in favor of the clear glass. It has not been found practical to place tantalum lamps on some of the older cars having center fixtures which hold the lamps at an angle greater than fifteen degrees with the vertical.—*The Sibley Journal*, October, 1910.

NEW CHRYSLER CAR-A-MINUTE ASSEMBLY PLANT



ADMINISTRATION BLDG. — *Architects and Engineers:* SVERDRUP & PARCEL, St. Louis • *General Contractor:* FRUIN-COLNON CONTRACTING CO., St. Louis
ASSEMBLY BLDG. — ALBERT KAHN, *Associated Architects and Engineers,* Detroit • H. D. TOUSLEY CO., *General Contractor,* Kirkwood, Mo.

Designed to hold down upkeep... equipped with JENKINS VALVES

Chrysler Corporation's St. Louis assembly plant serves the midwest, employs more than 4000 in building Valiant, Plymouth, Dodge Dart and new Dodge Lancer cars. Seven buildings include a 1.3 million square-foot manufacturing building and a U-shaped administration building of reinforced concrete columns and girders, with pre-cast concrete floor and roof deck.

Designed to be "the nation's most modern automobile manufacturing facility," this huge new plant also represents an all-out effort to make it a record-breaker in terms of low upkeep.

That Jenkins Valves would minimize valve maintenance and replacement costs was assured by the service records of Jenkins Valves in other Chrysler Corporation plants.

By installing Jenkins Valves to control customary service lines and the extensive paint carrying system in the St. Louis plant, Chrysler guaranteed dependability and economy. Yet, the Jenkins Valves cost no more.

You can take the gamble out of valve costs with one word in your specifications or purchase order . . . the word for economy: "JENKINS." For information about specific valves, ask your local Jenkins Distributor or write—Jenkins Bros., 100 Park Ave., New York 17.

Jenkins Gate Valves control lines carrying paint as well as plumbing, heating, air conditioning.

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There are many opportunities for mechanical engineers at Bethlehem Steel

You'll find a mechanical engineer designing complex machinery for a new rolling mill. Another is supervising construction of a giant blast furnace. Another is developing improved production methods. Others design tools, are in charge of plant maintenance divisions, or head up fuel departments. Others are in sales work. In fact, Bethlehem's president is a mechanical engineer.

The point is simple: there's virtually no limit to the opportunities at Bethlehem Steel for men trained in mechanical engineering.

If you're looking for a real opportunity to put your training to work, with a company that appreciates the talents of mechanical engineers and has plenty of use for them, look into the possibilities at Bethlehem Steel.

Bethlehem offers excellent career opportunities for men in virtually all engineering curricula: metallurgical, electrical, chemical, industrial, civil, mining, ceramic, architectural, and others. We suggest that you discuss Bethlehem with your Placement Officer. And be sure to pick up a copy of our booklet, "Careers with Bethlehem Steel and the Loop Course."

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STRESS *and* STRAIN...

Edited by D. J. Martin, ME '62

Patient: "Doc, my memory is going bad."
Doctor: "How do you know?"
Patient: "How do I know what?"

• • •

Beg your pardon, but aren't you an engineering student?"

"No, it's just that I couldn't find my suspenders this morning, my razor blades were gone, and a bus ran over my hat."

• • •

It's a fact: If you drink a gallon of milk a month for 1200 months, you'll live to be a hundred years old.

• • •

The baby sardine saw its first submarine and went swimming in terror to its mother. "Don't be frightened, darling," she reassured him, "It's only a can of people."

• • •

Little Johnny came home from school crying. "Hey, Ma, all the boys are picking on me. They say I have a big head."

"You don't have a big head, Johnny. Now run along and play."

The same thing happened the next day and the next, and each time Johnny's mother comforted him. The fourth day Johnny came home with the same story.

"For once and for all, Johnny, you don't have a big head. Now please go down town and get me ten pounds of potatoes."

"O.K., Ma, give me a sack."

"Sack? What do you need a sack for? Use your cap."

• • •

"Give me another pound of your ant powder," said the ChE rushing into the store.

"I'm glad to see that you like the powder," said the clerk.

"Yes," snapped the customer, "I've got one ant unconscious with the first pound and I figured I'll be able to kill him with the second."

• • •

A railroad agent in Africa had been bawled out for doing things without orders from headquarters. One day his boss received the following startling telegram: "Tiger on platform eating conductor. Wire instructions."

• • •

Typist: "But professor, isn't this the same exam you gave last year?"

Professor: "Yes, but I've changed the answers."

• • •

Two co-eds were discussing their favorite subject: men.

"If I came home and found an engineer in my apartment," gasped the freshman, "I wouldn't know what to do."

"You could give him forty-eight hours to get out," suggested the senior.

• • •

Second: "Well old man, I'm afraid you're licked now."

Boxer (gazing dizzily across to opposite corner): "Yeah I shoulda got him in the first round when he was alone."

• • •

A small boy, whose father was an engineer, paused before he said his good-night prayers.

"Mother, will I go to heaven sometime?" he asked.

"Yes, dear, if you're good."

"And will you be there?" he asked.

"I hope so, and Daddy will be there, too."

The little man shook his head emphatically. "My Daddy won't be there, he couldn't finish his lab report in time."

• • •

Truck driver stopped beside stalled Volkswagen on highway: "What's the matter buddy, need a new flint?"

• • •

A preacher recently announced that there are 735 sins.

He is being besieged with requests for the list, mostly from college students who think they're missing something.

A sweet old lady, always eager to help the needy, spied a particularly sad-looking old man standing on a street corner. She walked over to him, pressed a dollar into his hand and said, "Chin up." The next day, on the same corner, the sad old man shuffled up to the lady and slipped ten dollars into her hand. "Nice picking," he said in a low voice. "He paid nine to one."

• • •

Little Susie was at the question stage.

"Mama," she asked, "when I grow up and get married, will I also get a husband like daddy?"

"Indeed you will," smiled Mama.

"And if I don't get married, will I be an old maid like Aunt Mathilda?"

"That's right," agreed Mama.

"Gosh," mourned little Susie, "either way a woman can't win!"

• • •

If we want to make a new world we have the original materials ready. The first one was made out of chaos.

• • •

The boss sent the new engineer out to do the first job on his own.

"Just go ahead and use common sense," he told him.

"Sir," he gravely replied, "common sense is a rare gift of God. All I have is a B.S. degree."

• • •

An Englishman once took a trip to Ireland to inspect an estate that he had inherited. As he was walking through one of the gardens of the estate, an Irish farmer approached him and asked, "How did you acquire this land?"

"I inherited it from my father," was his answer.

"How did your father get it?"

"He inherited it from his father."

"How did he get it?"

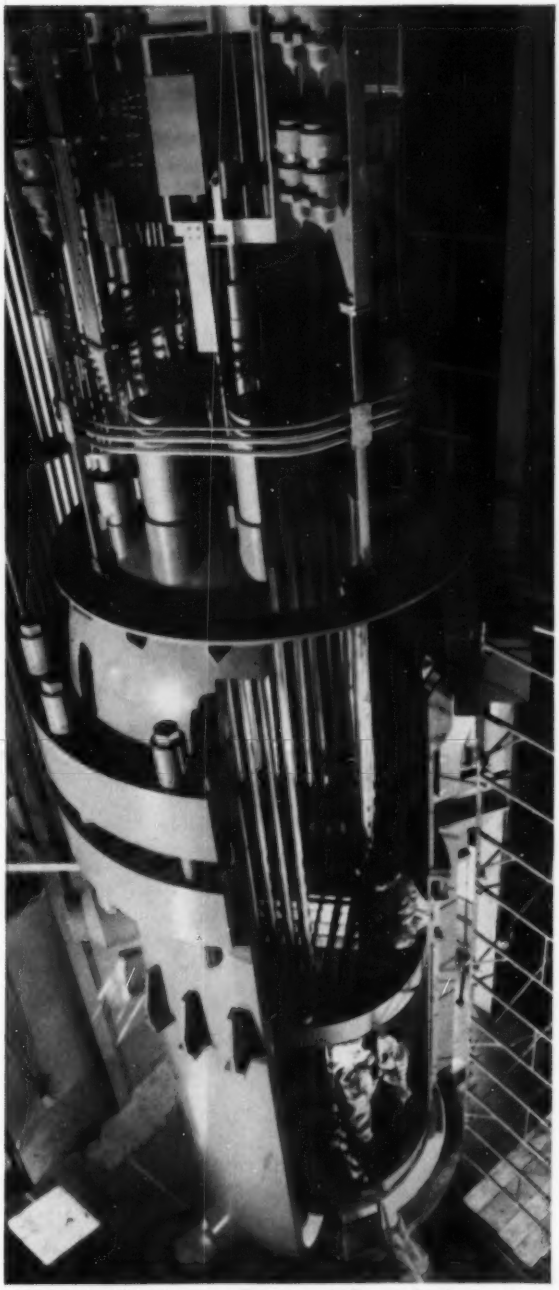
"He inherited it from his father."

"How did his father get it?" asked the Irishman.

"He fought for it."

"Take off your coat."

If your sights are set  on nuclear power–



ck-up of the Shippingport (Pa.) Atomic Power Station reactor
ch was designed and developed by the Westinghouse Electric
poration under the direction of and in technical cooperation
the Naval Reactors Branch, U.S. Atomic Energy Commission.

–you'll find **Photography at Work** with you

Already engineers working with nuclear power have learned that only utmost purity of materials and meticulous accuracy in manufacture can be tolerated in a reactor. Steels for the reactors and reactor vessels are checked for make-up and molecular structure with photomicrography and x-ray diffraction. Welds are proved sound and moderators flawless with radiography. And stresses likely to occur are studied in advance with photo-elastic stress analysis.

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So, in whatever you plan to do, take full advantage of all the ways photography can help.

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One of a series

Interview with
General Electric's Byron A. Case
Manager—Employee Compensation Service

Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

Q Mr. Case, what starting salary does your company pay graduate engineers?

A Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

Q How do you go about evaluating my ability and potential value to your company?

A We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

Q When could I expect my first salary increase from General Electric and how much would it be?

A Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

Q How much can I expect to be making after five years with General Electric?

A As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have five years' experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

Q What kinds of benefit programs does your company offer, Mr. Case?

A Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to *50 percent* of the employee's investment, subject to a prescribed holding period.

If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.

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